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NEW STRATEGIES IN EMERGENCY TRAINING

Felipe Fernández Méndez

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Novas estratexias en formación en emerxencias

D. Felipe Fernández Méndez

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A Martín e Olivia

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CONTENTS

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DE SANTIAGO
DE COMPOSTELA

LIST OF PUBLICATIONS

1. Fernández-Méndez F, Barcala-Furelos R, Otero-Agra M, Fernández-Méndez M, Santos-Folgar M, Rodríguez-Núñez A. **Evaluation of the thoracic compression technique using APPs. Do they help or hinder cardiopulmonary resuscitation?** Med Intensiva. 2018 Sep 27; pii: S0210-5691(18)30244-4. doi: 10.1016/j.medin.2018.07.015. [Epub ahead of print] English, Spanish. PMID: 30270143

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GENERAL CONTENTS

RESUMEN

Nuevas estrategias en formación en emergencias

INTRODUCCIÓN

Un alto número de muertes prehospitalarias por traumatismos ocurren con lesiones que son potencialmente recuperables aunque la intervención en primeros auxilios es infrecuente (1-4).

Esta primera atención pasa por el reconocimiento de la emergencia y la alerta a los servicios de emergencias. Esta alerta inicial se realiza de forma correcta en la mayoría de los casos pero se asocia, en el caso de que se efectúe de manera incorrecta, con una menor probabilidad de tratamiento por parte de los servicios médicos de emergencias y peores resultados de supervivencia (5).

El tiempo que transcurre desde el inicio de los síntomas, en el caso de un posible infarto de miocardio, hasta la búsqueda de atención no ha mejorado significativamente (6,7) a pesar de los avances en su tratamiento.

De manera similar, en el caso de accidente cerebrovascular, siguen existiendo dificultades en el reconocimiento de los síntomas y búsqueda de tratamiento por parte de pacientes y familias (8–13). En este sentido, a pesar de las iniciativas de educación pública y recomendaciones de práctica clínica persisten importantes lagunas en la identificación oportuna de los síntomas y la iniciación de los primeros auxilios (14–16).

La mayoría de las muertes por traumatismos se producen en el lugar del incidente, a menudo antes de la llegada de los servicios de

emergencias médicas (SEM) (17,18). Entre un 6 y 20% de las muertes prehospitalarias por traumatismo ocurren con lesiones que son potencialmente recuperables (3,19,20). Después de un incidente potencialmente mortal, los testigos tienen la oportunidad de iniciar los cuidados necesarios. Sin embargo la intervención de primeros auxilios por testigos es poco frecuente y muy variable, oscila entre el 10.7% y el 65, proporcionando primeros auxilios de forma incorrecta hasta en un 83.7% de los casos (21).

En este tipo de situaciones los testigos con poca o ninguna capacitación, pueden ser un eslabón esencial en la "cadena de supervivencia" de las emergencias sanitarias críticas (22) aplicando in situ y de inmediato los primeros auxilios.

Proceso de enseñanza-aprendizaje de habilidades en adultos.

El aprendizaje de adultos presenta desafíos que no se observan en la población estudiantil joven. Los adultos poseen experiencias, rasgos de personalidad, patrones de relación que determinan sus acciones (23). A los adultos les gusta que su aprendizaje se centre en problemas y tenga aplicabilidad práctica. Aprenden mejor cuando pueden aplicar inmediatamente lo que han aprendido (24).

Los métodos tradicionales de enseñanza basados en modelos expositivos no son eficaces en la formación de adultos. La vida media estimada de los conocimientos profesionales adquiridos a través de la educación formal puede ser de tan solo 2 a 2.5 años (25). En el caso de las actividades que requieren tanto conocimientos formales como un conjunto básico de habilidades, como el soporte vital, la retención puede ser de tan sólo 6 semanas (26–31).

Se sabe que las habilidades de RCP se deterioran en poco tiempo tras el entrenamiento (26-32) por lo que utilizar principios educativos basados en evidencia es fundamental para la optimización de la formación.

Evaluación de competencias en emergencias.

El éxito de los cuidados en situación de emergencia requiere habilidades cognitivas, psicomotoras y conductuales. Existe un énfasis cada vez mayor en centrar la formación y evaluación del alumno en el aprendizaje de dominio (33), la adquisición de la Maestría de McGaghie (34) o en los niveles más altos de la descripción de Miller (35).

La evaluación de estos niveles de habilidad requiere del uso de métodos evaluativos adecuados.

La evaluación de habilidades constituye un reto en si misma debido a que no todos los métodos de evaluación son útiles para los diferentes niveles de competencia (36). Una limitación de la evaluación es que puede no demostrar un desempeño futuro real. La evidencia de que la evaluación protege al público de una atención de mala calidad es tanto indirecta como escasa; consiste en unos pocos estudios que muestran correlaciones entre los programas de evaluación que utilizan métodos múltiples y estimaciones relativamente rudimentarias de la calidad, como las pruebas de diagnóstico, la prescripción y los patrones de remisión (37).

Correlacionar la evaluación con el desempeño futuro es complejo, no solo debido al propio proceso de evaluación sino a la limitación de la formación y su relación con el desempeño futuro.

Estrategias innovadoras en formación en emergencias.

La Organización Mundial de la Salud (OMS), numerosas sociedades científicas internacionales así como diversas investigaciones han considerado el impacto potencial del uso de las tecnologías digitales como mecanismo para actuar sobre la salud (32, 38-45).

Las nuevas tecnologías tienen el potencial de transformar no solo la formación y evaluación sino la prestación de servicios sanitarios.

Sistema de seguimiento visual y su posible papel en la formación de adultos (Eye tracking o seguimiento pupilar automático).

El sistema de seguimiento visual es un concepto bien establecido desde que se utilizó por primera vez en 1950 para estudiar el comportamiento visual de pilotos (46). Este sistema cuenta con un dispositivo que enfoca una cámara hacia el ojo del sujeto de manera que pueden grabarse los movimientos pupilares para ser posteriormente analizados.

El seguimiento ocular mide el comportamiento de la mirada durante la ejecución de la tarea, lo que permite conocer datos sobre la toma de decisiones.

El desarrollo de métodos válidos, fiables y objetivos de evaluación de habilidades es fundamental para la formación (47). En este sentido el sistema de rastreo ocular es un método utilizado para la evaluación (48-62) pudiendo medir diferentes niveles de habilidad (48-50,52,54,55,58,60,63-65).

Oportunidades que las nuevas tecnologías ofrecen a la formación en el campo de las emergencias.

En el año 2003, Chamberlain y Hazinski (66) estimaron el funcionamiento de la cadena de supervivencia a nivel local, que depende fundamentalmente de legos, y establecieron un ideal a alcanzar. Este ideal tendría el potencial de salvar vidas de pacientes víctimas de una situación de emergencia en PCR.

La Asociación Americana del Corazón (AHA), en el año 2018, en el documento “Estrategias educativas para mejorar los resultados del paro cardiaco” (42) indica que la fórmula para la supervivencia depende fundamentalmente de la eficiencia educativa y la implementación local de programas formativos, siendo estos dos factores, determinantes en la supervivencia.

Estas fórmulas de la supervivencia muestran el potencial que intervenciones adecuadas sobre primeros intervinientes pueden tener sobre la supervivencia ante una situación de emergencia.

La baja participación de primeros intervinientes en situación de emergencia ofrece una oportunidad para la mejora. Una formación y evaluación eficientes, acordes a la evidencia científica así como el uso y aprovechamiento de las nuevas tecnologías tienen el potencial de salvar miles de vidas de víctimas de situación de emergencia (45). En este sentido el uso de la simulación y del sistema de seguimiento visual pueden ser tecnologías útiles para alcanzar estos objetivos.

HIPÓTESIS

- La simulación y el sistema de seguimiento pupilar automático (eye-tracking) son herramientas útiles para evaluar y conocer el grado de desempeño en situaciones simuladas.
- Las aplicaciones móviles con retroalimentación en tiempo real mejoran la calidad de la RCP realizada por legos.
- La realización de RCP por legos con un teléfono móvil entre las manos disminuye la calidad de la RCP.
- Los socorristas profesionales con formación teórica en valoración primaria realizan, en una situación simulada, valoración primaria de forma deficiente.
- Durante una simulación con paciente crítico, socorristas profesionales centran su atención en el paciente.
- La formación presencial es más efectiva para el reconocimiento y tratamiento de la anafilaxia que la formación mediante vídeo.
- Ante un caso simulado, los profesores centrarán sus fijaciones visuales en la víctima de anafilaxia.
- Tras recibir formación con vídeo o formación cara a cara los profesores realizarán un tratamiento adecuado de la anafilaxia.

OBJETIVOS

Los objetivos principales y secundarios de esta investigación son;

1. Valorar el uso de la simulación y la tecnología de seguimiento pupilar automático (eye-tracking) como método de evaluación del desempeño en diversas situaciones de emergencia.
2. Evaluar la calidad de la reanimación cardiopulmonar (RCP) de personas no expertas guiada por aplicación móvil con retroalimentación en tiempo real.
    2.1. Evaluar si la realización de la RCP con un teléfono móvil entre las manos interfiere en la calidad de la reanimación.
3. Valorar la toma de decisiones y el grado de desempeño en valoración primaria ante una situación simulada por parte de socorristas.
    3.1. Conocer el patrón visual de socorristas en la valoración de una situación crítica simulada.
4. Comparar en un entorno simulado la utilidad de dos modelos formativos (vídeo vs presencial) para el reconocimiento y tratamiento de la anafilaxia.
    4.1. Conocer el patrón visual de profesores en la resolución de una simulación con un paciente con anafilaxia.
    4.2. Determinar el nivel de competencia de profesores ante una situación simulada de anafilaxia.

RESULTADOS

Esta tesis sigue la modalidad de compendio de artículos. Por lo tanto los resultados se presentan como artículos de investigación.

1. **Evaluación sobre la técnica de compresiones torácicas usando APP. ¿Ayudan o entorpecen la reanimación cardiopulmonar?**

El objetivo de este estudio fue evaluar la calidad de la reanimación cardiopulmonar (RCP) de personas no expertas guiada por una aplicación móvil con retroalimentación en tiempo real.

Se realizó un estudio cuasi-experimental de corte transversal. Una muestra de 113 estudiantes de Enfermería sin experiencia ni formación en RCP participaron en el estudio. Se realizaron tres test de RCP solo manos con compresiones continuas: 1)RCP sin dispositivo, 2)RCP con el teléfono apagado, 3)RCP guiada por aplicación móvil. Se aleatorizaron tres aplicaciones diferentes [Pocket CPR®, CPR Pro® y Massage cardiaque et DSA®]. Los tres test se realizaron de forma consecutiva, aleatorizados y separados 30 minutos entre cada uno. Se utilizó el maniquí Laerdal Resusci Anne QCPR (Stavanger, Norway) software 2.0.0.14.

La calidad global de la RCP fue de 33,3%+32,7 para Pocket CPR, 10,9%+22,72 para CPR Pro y 7,8%+9,2 para Massage cardiaque et DSA. Con ninguna de las aplicaciones móviles se consiguen mejorías estadísticamente significativas. El porcentaje de tiempo que el reanimador consiguió mantener el ritmo correcto mejoró con el uso de las tres APP.

En conclusión, la RCP guiada por aplicaciones móviles no mejoró la calidad global de las compresiones durante la reanimación, si bien mejoró el porcentaje de compresiones realizadas a un ritmo correcto.

Limitaciones: Este es un estudio con maniquíes por lo que los resultados pueden no ser trasladables a la práctica clínica. Los

resultados del uso de una aplicación móvil en una víctima real o en un escenario que no sea simulado pueden generar datos diferentes. Todos los participantes usaron el mismo teléfono inteligente, esto también puede ser un factor limitante ya que no todos los teléfonos tienen los mismos tamaños y las mismas prestaciones, por tanto los hallazgos tienen que ser tomados con precaución. La falta de entrenamiento técnico para la sujeción del teléfono inteligente o la falta de experiencia de los sujetos puede ser otro factor limitante.

2. **Valoración ABCDE por parte de socorristas: ¿Cómo manejan a un paciente crítico? Un estudio de simulación transversal.**

El objetivo de este estudio fue evaluar la toma de decisiones, la capacidad en el uso de la valoración ABCDE y las habilidades de abordaje de los socorristas al enfrentarse a un caso simulado que requiere cuidados críticos.

Se diseñó un estudio de simulación transversal para evaluar las habilidades y secuencia de valoración ABCDE en 20 socorristas profesionales. Se recogieron variables demográficas, así como variables relacionadas con la habilidad de valoración ABCDE y variables de valoración ABCDE con sistema de seguimiento visual (eye-tracking).

La evaluación de los sujetos fue realizada por tres instructores en soporte vital básico y soporte vital avanzado así como por el sistema Mobile Eye (Bedford, USA).

Ninguno de los participantes del estudio consiguió completar de forma correcta la valoración primaria. En torno al 60% de las fijaciones y del tiempo de fijaciones fue dedicado a zonas de visión importantes para el abordaje ABCDE, encontrándose diferencias significativas al compararlo con las zonas de visión sin importancia ($p < 0.008$)

En conclusión, los socorristas de este estudio toman la iniciativa para realizar la valoración ABCDE, sin embargo el orden de la secuencia es variable y la precisión de las habilidades no es la adecuada. La evaluación por expertos con la ayuda de la tecnología de seguimiento pupilar identifica las limitaciones en la valoración y tratamiento, pudiendo ser una herramienta útil para el entrenamiento de socorristas.

Limitaciones: Este es un estudio de simulación por lo que una intervención real podría generar resultados diferentes. La falta de experiencia de los participantes en el uso de la simulación podría ser un factor limitante.

3. Aprendizaje y tratamiento de la anafilaxia por legos: Un estudio de simulación utilizando tecnología pupilar

El objetivo de este estudio fue evaluar dos modelos de formación sobre el reconocimiento y tratamiento de la anafilaxia para personas legas, basado en la valoración de expertos y la tecnología pupilar.

Se realizó un estudio de simulación cuasi-experimental de corte transversal para evaluar la identificación y tratamiento de la anafilaxia. 50 sujetos fueron randomizados en 4 grupos: 3 usaron diferentes videos con contenido supervisado por un equipo sanitario y se comparó con una formación cara a cara en consulta pediátrica. Para la evaluación del aprendizaje se diseñó un escenario de simulación en el que se representaba una víctima de anafilaxia. Se utilizó un dispositivo de registro de los movimientos oculares y la valoración de expertos para evaluar el desempeño.

La formación pediátrica cara a cara obtuvo un mejor y más rápido reconocimiento de la anafilaxia. Los participantes usaron el inyector de adrenalina con mayor precisión y menos errores. Con este tipo de formación, los participantes, necesitaron un menor número de fijaciones visuales para reconocer la anafilaxia y tomar la decisión de inyectar la epinefrina.

En conclusión, una formación cara a cara impartida por un pediatra, mejora el reconocimiento de la anafilaxia y la probabilidad de la utilización correcta de un inyector. Los vídeos formativos pueden ser un recurso útil, pero con gran variabilidad en su eficacia.

Limitaciones: Al igual que con otros estudios de simulación los resultados deben considerarse con cautela en caso de víctimas reales.

DISCUSIÓN

El objetivo principal de este trabajo ha sido la evaluación de diversas situaciones simuladas para el estudio y comprensión de las habilidades, aprendizaje y aplicación de técnicas de primeros auxilios por testigos tanto legos como con obligación de intervenir.

Esta investigación ha tratado de aportar evidencias sobre las nuevas tecnologías y metodologías formativas. En nuestro conocimiento, esta es la primera investigación que aborda de forma global el uso de la retroalimentación así como la simulación y evaluación con sistema de seguimiento visual en personal no sanitario.

Retroalimentación mediante aplicaciones móviles.

El desempeño inadecuado de la RCP es común pero difícil de detectar para los proveedores e instructores (67,68). En teoría, la tecnología podría ayudar a abordar este problema evaluando el rendimiento de la reanimación cardiopulmonar y proporcionando retroalimentación. En este sentido los dispositivos de retroalimentación que proporcionan información sobre profundidad de las compresiones, ritmo, reexpansión y posición de manos durante el entrenamiento mejoran el nivel de adquisición de competencias al final de la formación (26,69-89).

Las aplicaciones móviles han revolucionado en muchos aspectos el aprendizaje de la RCP (90) o la activación de testigos próximos a

accidentes logrando un incremento en la realización de RCP por partes de primeros intervinientes (91-93).
Existen numerosas investigaciones sobre la RCP con retroalimentación y la mejora de la calidad de la reanimación tanto de legos como profesionales de la salud (26,79,94–96). La tecnología móvil mediante el uso de aplicaciones móviles pretende ofrecer al primer interviniente una herramienta que proporcione retroalimentación en tiempo real de la RCP realizada. Nuestro estudio investigó la eficacia de las compresiones torácicas comparando tres aplicaciones móviles.

Los sujetos de este estudio no mejoraron los resultados con la RCP guiada por aplicaciones móviles y en algunos casos incluso empeoraron. Otros estudios han mostrado que diferentes dispositivos que ofrecen retroalimentación aumentan la calidad de las compresiones torácicas especialmente ritmo y profundidad, cuando son utilizados por personas con formación en RCP (84,97). Los estudiantes de esta investigación no tenían formación previa y su primer contacto con la RCP fue la familiarización inicial con la aplicación móvil antes de los test. La falta de práctica instrumental puede ser un importante factor limitante.

Las aplicaciones móviles de este estudio no mejoraron la profundidad de la compresión, quizá por la falta de habilidad de los reanimadores, por la falta de precisión de la aplicación móvil o por la incomodidad que puede generar realizar RCP con el teléfono enlazado en las manos. Otros dispositivos que liberan las manos están disponibles en el mercado y pueden ser una alternativa (98).

La profundidad de las compresiones ha sido insuficiente en todos los test realizados, aun con el uso de las aplicaciones móviles. No llegar a la profundidad adecuada es un factor concurrente en numerosos estudios con legos (99). Diversos motivos pueden provocar una carencia en la profundidad. Sin embargo el uso de las aplicaciones móviles han conseguido mantener la frecuencia de compresiones en

valores significativamente superiores cuando fue comparada con los otros test. En la RCP guiada por dispositivos con retroalimentación, se han encontrado mejoras en cuanto al ritmo (100-101). Sin embargo, elementos simples como música, dispositivos led o metrónomos pueden mejorar esta variable (100) sin la necesidad de ocupar las manos aunque existen pruebas de que pueden reducir la profundidad de la compresión a medida que el sujeto se concentra en el ritmo correcto (76,88,89).

El uso de un dispositivo de retroalimentación debe utilizarse cuando existen pruebas estadísticas de validez y fiabilidad como herramienta de medición (102). En esta línea y siguiendo las recomendaciones de la Administración de Alimentos y Drogas de los Estados Unidos (US Food and Drug Administration) (103) es necesario una regulación sobre las aplicaciones móviles médicas de forma que se asegure su validez y fiabilidad. Por lo que el uso de estrategias digitales debe ser evaluado de manera similar a otras intervenciones médicas, incluyendo evaluaciones formales tales como los 6 dominios de la calidad de la atención médica identificados por el Instituto de Medicina: seguridad, eficacia, centrada en el paciente, oportuna, eficiente y equitativa (104).

En ocasiones los mecanismos diseñados para mejorar la RCP, si no se tiene la formación, el entrenamiento o la experiencia, no consiguen su finalidad. Por lo que el uso de dispositivos de retroalimentación durante la RCP solo se deben tener en cuenta como parte de un sistema de atención más amplio (105) en lugar de como una intervención aislada.

Sistema de seguimiento pupilar automático (eye-tracking). Simulación.

La simulación es una potente herramienta que permite entrenar y mejorar las habilidades (106) habiendo demostrado ser altamente efectiva para el entrenamiento de eventos críticos (107,108). La simulación permite a los educadores crear experiencias realistas que

fomentan el aprendizaje en un entorno que no compromete la seguridad del paciente (109), así como entrenar un rango de roles desde la primera respuesta ante la PCR hasta la dirección de un equipo de RCP.

El entrenamiento con simulación es una parte integral del entrenamiento en emergencias. Una revisión sistemática y meta-análisis de 182 estudios que incluyó a 16.636 participantes en formación con simulación para la reanimación mostró una mejora en el conocimiento y en el desempeño de las habilidades comparadas a la formación sin simulación (110).

El uso de métodos válidos, confiables y objetivos de evaluación de habilidades en situaciones críticas es fundamental en la formación moderna. La simulación de alta tecnología se considera cada vez más como una ayuda importante para el aprendizaje y puede resultar útil en la evaluación del conocimiento, el razonamiento clínico y el trabajo en equipo (111,112).

De igual modo el sistema de seguimiento visual ha sido propuesto como una herramienta de evaluación potencial utilizada en múltiples ámbitos y diversos estudios (48-65).

La tecnología de seguimiento pupilar permite reconocer las variables visuales (48,49,53,58,59,62,63,113-115) y establecer patrones que ayuden a entender el razonamiento clínico implicado en la toma de decisiones.

Utilizando estas tecnologías (simulación y sistema de seguimiento pupilar) hemos llevado a cabo las primeras investigaciones en las que se evalúa la atención proporcionada en situaciones de emergencia por personal no sanitario.

El socorrista es la persona encargada de la seguridad (116) prevención y rescate (117) en los ambientes acuáticos. La atención de primeros auxilios no es una tarea habitual ya que representa un porcentaje muy bajo del total de acciones que realizan los socorristas (118), sin

embargo cuando el incidente ocurre, cada segundo cuenta y se deben prestar cuidados adecuados y de calidad. Se ha pretendido conocer la capacidad de socorristas en el uso de la valoración primaria utilizando simulación y el sistema de seguimiento visual.

Los socorristas profesionales mostraron diferencias a la hora de reconocer y tratar a un paciente crítico en una situación simulada. Todos los participantes del estudio tenían formación teórica y sabían qué era y como se aplicaba la valoración primaria, pero no habían recibido formación con simulación y un 55% no había utilizado la valoración primaria en una situación real.

Los socorristas de este estudio evaluaron la A (vía aérea) (70%) y la B (respiración) (85%) aunque solo lo hicieron de forma correcta el 20% en cuanto a la vía aérea y el 25% para la respiración. De hecho la valoración de la respiración fue realizada correctamente por 5 sujetos. Solo un 40% evaluó la C (circulación). De los sujetos que realizaron la evaluación de la circulación sólo 3 tomaron pulso central y 2 pulso periférico. A pesar de que este paso, la valoración de la circulación fue lo que más tiempo precisó (45 seg). Puede que esto fuera debido a la hemorragia que presentaba el simulador en el miembro inferior. La hemorragia era un factor distractor introducido por los investigadores. Ésta era de muy escasa cuantía, producida por una erosión. La mayor parte de sujetos de este estudio no se plantearon valorar los pulsos ni periférico ni central. Esto podría deberse a que las Guías del Consejo Europeo de Resucitación (ERC) (119) así como las Guías de la Asociación Americana del Corazón (AHA) (120) de soporte vital básico insisten en que tomar el pulso no es una medida necesaria para establecer el diagnóstico de parada cardiorrespiratoria. Sin embargo el simulador no presentaba una PCR y precisaba valoración de la circulación.

La aplicación de un sistema estructurado de valoración se ha convertido en la norma en trauma. Este enfoque para el reconocimiento precoz y el tratamiento de lesiones potencialmente

mortales ha sido entrenado en cursos de trauma durante décadas (121,122). En el estudio de Olgers et al. en el que investigaron el uso del enfoque ABCDE por médicos de un servicio de urgencias observaron que este enfoque fue utilizado en el 26% de los pacientes. Cuando el abordaje secuncial ABCDE fue utilizado se hizo con altas puntuaciones (83%). El motivo por el que los médicos decidieron no utilizar este enfoque de valoración fue por la impresión clínica general, los signos vitales registrados por enfermería o que el motivo de la consulta no sugiere paciente inestable (123). En otro estudio realizado en un servicio de urgencias hospitalarias se encontraron que el 52% de los pacientes fueron evaluados con la sistemática ABCDE pero sólo se realizó de forma completa y con precisión en el 17% (124).

A la vista de nuestros resultados parece que los socorristas de nuestra investigación se encuentran por debajo en cuanto a cumplimiento del protocolo ABCDE. Con respecto a las fijaciones visuales los socorristas mantienen una adecuada atención y fijación, es decir están centrados en mirar. En torno al 60% de las fijaciones y del tiempo de fijaciones visuales fue dedicado a zonas de visión importantes para el abordaje ABCDE. Esto es independiente a las decisiones tomadas en cada momento. Puede estar centrando su mirada pero no saber las decisiones a tomar.

Seguimiento pupilar automático. Simulación. Paciente estandarizado.

Los pacientes estandarizados son actores que están entrenados para retratar a los pacientes consistentemente en ocasiones repetidas (111). Las interacciones con pacientes estandarizados pueden adaptarse para cumplir objetivos educativos específicos de modo que los actores que representan a los pacientes pueden calificar el desempeño del interviniente en la simulación. Las evaluaciones estructuradas con el uso de pacientes estandarizados son tan confiables como las calificaciones de los encuentros directamente observados con

pacientes reales (125-127). Mediante el uso de un paciente estándar y el sistema de seguimiento pupilar automático evaluamos dos modelos de formación (video vs. cara a cara o presencial) y su aplicación en un caso simulado de anafilaxia.

Diferentes sistemas de formación mediante video han reportado éxito en la enseñanza de técnicas relacionadas con las emergencias (128,129). En nuestro estudio, la formación tradicional cara a cara proporcionada por personal experto ha obtenido mejores resultados que la formación en video. Contrariamente diversos estudios sobre RCP habían mostrado buenos resultados para la formación mediante vídeo (128,130).

Los sujetos del grupo que ha recibido la formación cara a cara o presencial con un instructor son los segundos más rápidos a la hora de tener el inyector en la mano y los más rápidos a la hora de utilizar y administrar la epinefrina. El grupo "cara a cara" ofrece el tratamiento adecuado a la anafilaxia en 36±21,5 seg desde el inicio del escenario. Johnston, EB et al (131) encontraron en un estudio realizado con residentes de anestesia en un simulación intraoperatoria que el tiempo promedio de diagnóstico de la anafilaxia fue de 7,6±2,4 min y el tiempo para administrar la epinefrina 6,5 ± 2,1 min. Se necesita un mayor énfasis en el pronto reconocimiento y tratamiento apropiado de la anafilaxia por profesionales de la salud (132).

El estudio de Arga, M et al (133) en el que evaluaron la habilidad de médicos en el uso de inyectores de epinefrina antes y después de recibir formación teórico-práctica vieron que los errores en el uso de los autoinyectores pueden estar relacionados con el diseño del mismo. En nuestro estudio hemos observado que el inadecuado manejo del autoinyector es más frecuente en los grupos formados mediante vídeo. El grupo que recibió la formación cara a cara no cometió ningún error en su manipulación.

A la vista de los resultados parece que en nuestro estudio los errores en la manipulación del inyector están más relacionados con la

formación recibida que con el propio diseño del autoinyector. En el estudio de Grouhi, M. et al (134) en el que se evaluaron las habilidades de médicos, enfermeros y farmacéuticos en el uso de autoinyectores de epinefrina, la mayoría de participantes un 75% no demostraron la capacidad de usar el dispositivo de manera adecuada. En nuestro estudio los porcentajes varían de un 100% de uso no adecuado a un 61,5% dependiendo de la formación recibida.

Los sujetos que han recibido la formación presencial reconocen de forma más rápida y con menores fijaciones visuales los síntomas propios de la anafilaxia y tienen más probabilidad de administrar con eficacia el tratamiento de la anafilaxia. Estos sujetos realizan menos fijaciones visuales en los signos de la anafilaxia que el resto de grupos. Esto puede deberse a que debido a su formación reconocen de forma más rápida los signos propios de anafilaxia por lo que no precisan tantas fijaciones. En cambio los dos grupos que más fijaciones visuales realizan son los que peor tratamiento ofrecen.

Los expertos, en comparación con los no expertos, presentan fijaciones de duración más corta, más fijaciones en áreas relevantes para las tareas y menos fijaciones en áreas redundantes (135). Existen diferentes patrones visuales en profesionales experimentados y novatos de modo que la identificación de las áreas de la mirada y el aumento de las fijaciones en los expertos permite la demostración de estos a los novatos lo que podría facilitar el aprendizaje y la habilidad (47). La mirada y las fijaciones pueden entrenarse. En campos como en el deporte han demostrado mejoras en el rendimiento (136–138).

El reconocimiento de los patrones visuales puede ayudar a entender el razonamiento implicado en la toma de decisiones. El uso de la simulación junto al conocimiento obtenido a través de dispositivos de seguimiento de la mirada puede contribuir a la optimización de la formación y a la mejora de los resultados en la prestación de los primeros auxilios.

LIMITACIONES

Todas las investigaciones realizadas han sido con simulación, por lo que no podemos confirmar si estos resultados son generalizables al ambiente clínico real.

CONCLUSIONES

1. La simulación y la tecnología de seguimiento pupilar automático (eye-tracking) son herramientas útiles y confiables para la evaluación del desempeño en situación de emergencia.
2. Las aplicaciones móviles no suponen una ayuda para mejorar la calidad de las compresiones.
3. Realizar RCP con un teléfono móvil entre las manos no interfiere con la calidad de la RCP.
4. Los socorristas toman la iniciativa para realizar la evaluación primaria sin embargo el orden de la secuencia es variable y la precisión de las habilidades no es la adecuada.
5. Los socorristas mantienen una adecuada atención y fijación durante la situación simulada. En torno al 60% de las fijaciones y del tiempo de fijaciones visuales fue dedicado a zonas de visión importantes para el abordaje ABCDE.
6. La formación presencial con un instructor es un método más eficaz que la formación mediante vídeo para el reconocimiento y tratamiento adecuado de la anafilaxia.
7. El grupo de profesores que recibió la formación presencial (“cara a cara" con un instructor), en comparación con los otros grupos, reconoció de forma más rápida y con menores fijaciones visuales la anafilaxia.
8. La formación presencial con un instructor generó un tratamiento de la anafilaxia más rápido y correcto en comparación con los otros grupos.

RESUMO

Novas estratexias en formación en emerxencias

INTRODUCIÓN

Un alto número de mortes prehospitalarias por traumatismos ocorren con lesións que son potencialmente recuperables aínda que a intervención en primeros auxilios é infrecuente (1-4).

Esta primeira atención pasa polo recoñecemento da emerxencia e a alerta ós servizos de emerxencias. Esta alerta inicial realízase de forma correcta na maioría dos casos pero asociase, no caso de que se efectúe de maneira incorrecta, cunha menor probabilidade de tratamento por parte dos servizos médicos de emerxencias e peores resultados de supervivencia (5).

O tempo que transcorre dende o inicio dos síntomas, no caso dun posible infarto de miocardio, ata a búsqueda de atención non mellorou significativamente (6,7) a pesar dos avances no seu tratamento.

De maneira semellante, no caso de accidente cerebrovascular, seguen existindo dificultades no recoñecemento dos síntomas e a búsqueda de tratamento por parte de pacientes e familias (8–13). Neste sentido, a pesares das iniciativas de educación pública e recomendacións de práctica clínica persisten importantes lagoas na identificación oportuna dos síntomas e a iniciación dos primeiros auxilios (14–16).

A maioría das mortes por traumatismos prodúcense no lugar do incidente, a miúdo antes da chegada dos servizos de emerxencias

médicas (17,18). Entre un 6 e un 20% das mortes prehospitalarias por traumatismo ocorren con lesións que son potencialmente recuperables (3,19,20). Despois dun incidente potencialmente mortal, as testemuñas teñen a oportunidade de iniciar os coidados necesarios. Con todo, a intervención de primeiros auxilios por testemuñas é pouco frecuente e moi variable, oscila entre o 10.7% e o 65%, proporcionando primeiros auxilios de forma incorrecta até nun 83.7% dos casos (21).

Neste tipo de situacións as testemuñas con pouca ou ningunha capacitación, poden ser un elemento esencial na "cadea de supervivencia" das emerxencias sanitarias críticas (22) aplicando in situ e de inmediato os primeiros auxilios.

Proceso de ensino-aprendizaxe de habilidades en adultos.

A aprendizaxe de adultos presenta desafíos que non se observan na poboación estudantil moza. Os adultos posúen experiencias, trazos de personalidade, patróns de relación que determinan as súas accións (23). Aos adultos gústalles que a súa aprendizaxe se centre en problemas e que teña aplicabilidade práctica. Aprenden mellor cando poden aplicar inmediatamente o que aprenderon (24).

Os métodos tradicionais de ensino baseados en modelos expositivos non son eficaces na formación de adultos. A vida media estimada dos coñecementos profesionais adquiridos a través da educación formal pode ser de tan só 2 a 2.5 anos (25). No caso das actividades que requiren tanto coñecementos formais como un conxunto básico de habilidades, como é o caso do soporte vital, a retención pode ser de tan só 6 semanas (26–31).

Sábese que as habilidades de RCP se deterioran en pouco tempo tras o adestramento (26-32) polo que utilizar principios educativos baseados en evidencia é fundamental para a optimización da formación.

Avaliación de competencias en emerxencias.

O éxito dos coidados en situacións de emerxencia require habilidades cognitivas, psicomotoras e conductuais. Existe unha énfase cada vez maior en centrar a formación e avaliación do alumno na aprendizaxe do dominio (33), a adquisición da Mestría de McGaghie (34) ou nos niveis máis altos da descrición de Miller (35).

A avaliación destes niveis de habilidade require do uso de métodos avaliativos adecuados.

A avaliación de habilidades constitúe un reto en si mesma debido a que non todos os métodos de avaliación son útiles para os diferentes niveis de competencia (36). Unha limitación da avaliación sería que pode non demostrar un desempeño futuro real. A evidencia de que a avaliación protexe ao público dunha atención de mala calidade é tanto indirecta como escasa; baséase nuns poucos estudos que mostran correlacións entre os programas de avaliación que utilizan métodos múltiples e estimacións relativamente rudimentarias da calidade, como as probas de diagnóstico, a prescrición e os patróns de remisión (37).

Correlacionar a avaliación co desempeño futuro é complexo, non só debido ao propio proceso de avaliación senón á limitación da formación e a súa relación co desempeño futuro.

Estratexias innovadoras en formación en emerxencias.

A Organización Mundial da Saúde (OMS), numerosas sociedades científicas internacionais así como diversas investigacións, consideraron o impacto potencial do uso das tecnoloxías dixitais como mecanismo para actuar sobre a saúde (32, 38-45).

As novas tecnoloxías teñen o potencial de transformar non só a formación e avaliación senón tamén a prestación de servizos sanitarios.

Sistema de seguimento visual e o seu posible papel na formación de adultos (Eye tracking ou seguimento pupilar automático).

O sistema de seguimento visual é un concepto ben establecido desde que se utilizou por primeira vez en 1950 para estudar o comportamento visual de pilotos (46). Este sistema conta cun dispositivo que enfoca cunha cámara cara ao ollo do suxeito, de maneira que poden gravarse os movementos pupilares para seren posteriormente analizados.

O seguimento ocular mide o comportamento da mirada durante a execución da tarefa, o que permite coñecer datos sobre a toma de decisións.

O desenvolvemento de métodos válidos, fiables e obxectivos de avaliación de habilidades é fundamental para a formación (47). Neste sentido o sistema de rastrexo ocular é un método utilizado para a avaliación (48-62) podendo medir diferentes niveis de habilidade (48-50,52,54,55,58,60,63-65).

Oportunidades que as novas tecnoloxías ofrecen á formación no campo das emerxencias.

No ano 2003, Chamberlain e Hazinski (66) estimaron o funcionamento da cadea de supervivencia a nivel local, que depende fundamentalmente de legos, e estableceron un ideal para acadar. Este ideal tería o potencial de salvar vidas de pacientes vítimas dunha situación de emerxencia en PCR.

A Asociación Americana do Corazón (AHA), no ano 2018, no documento "Estratexias educativas para mellorar os resultados do paro cardíaco" (42) indica que a fórmula para a supervivencia depende fundamentalmente da eficiencia educativa e da implementación local de programas formativos, sendo estes dous factores, determinantes na supervivencia.

Estas fórmulas da supervivencia mostran o potencial que intervencións adecuadas sobre primeiros intervenientes poden ter sobre a supervivencia diante dunha situación de emerxencia.

A baixa participación de primeiros intervenientes en situación de emerxencia ofrece unha oportunidade para a mellora. Unha formación e avaliación eficientes, acordes á evidencia científica, así como o uso e aproveitamento das novas tecnoloxías teñen o potencial de salvar miles de vidas de vítimas de situación de emerxencia (45). Neste sentido o uso da simulación e do sistema de seguimento visual poden ser tecnoloxías útiles para alcanzar estes obxectivos.

HIPÓTESE

- A simulación e o sistema de seguimento visual automático (eye-tracking) son ferramentas útiles para avaliar e coñecer o grao de desempeño en situacións simuladas.
- As aplicacións móbiles con retroalimentación en tempo real melloran a calidade da RCP realizada por persoas leigas.
- A realización de RCP por persoas leigas cun teléfono móbil nas mans diminúe a calidade da RCP.
- Os socorristas profesionais con formación teórica en valoración primaria realizan, nunha situación simulada, valoración primaria de forma deficiente.
- Durante unha simulación con paciente crítico, socorristas profesionais centran a súa atención no paciente.
- A formación presencial é máis efectiva para o recoñecemento e tratamento da anafilaxia que a formación mediante vídeo.
- Ante un caso simulado, os profesores centrarán as súas fixacións visuais na vítima de anafilaxia.
- Tras recibir formación con vídeo ou formación cara a cara os profesores realizarán un tratamento adecuado da anafilaxia.

OBXECTIVOS

Os obxectivos principais e segundarios desta investigación son:

1. Valorar o uso da simulación e a tecnoloxía de seguimento pupilar automático (eye-tracking) como método de avaliación do desempeño en diversas situacións de emerxencia.
2. Avaliar a calidade da reanimación cardiopulmonar (RCP) de persoas non expertas guiada por aplicación móbil (APP) con retroalimentación en tempo real.
    2.1. Avaliar se a realización da RCP cun teléfono móbil entre as mans interfere na calidade da reanimación.
3. Valorar a toma de decisións e o grao de desempeño en valoración primaria ante unha situación simulada por parte de socorristas.
    3.1. Coñecer o patrón visual de socorristas na valoración dunha situación crítica simulada.
4. Comparar nunha contorna simulada a utilidade de dous modelos formativos (vídeo vs presencial) para o recoñecemento e tratamento da anafilaxia.
    4.1. Coñecer o patrón visual de profesores na resolución dunha simulación cun paciente con anafilaxia.
    4.2. Determinar o nivel de competencia de profesores ante unha situación simulada de anafilaxia.

RESULTADOS

Esta tese segue a modalidade de compendio de artigos. Por tanto os resultados preséntanse como artigos de investigación.

1. Avaliación sobre a técnica de compresións torácicas usando APP. Axudan ou entorpecen a reanimación cardiopulmonar?

O obxectivo deste estudo foi avaliar a calidade da reanimación cardiopulmonar (RCP) de persoas non expertas guiada por unha aplicación móbil con retroalimentación en tempo real.

Realizouse un estudo cuasi-experimental de corte transversal. Unha mostra de 113 estudantes de Enfermería sen experiencia nin formación en RCP participaron no estudo. Realizáronse tres test de RCP, só mans con compresións continuas: 1) RCP sen dispositivo, 2) RCP co teléfono apagado, 3) RCP guiada por aplicación móbil. Aleatorizáronse tres aplicacións diferentes [Pocket CPR®, CPR Pro® e Massage cardiaque et DSA®]. Os tres test realizáronse de forma consecutiva, aleatorizados e separados por 30 minutos entre cada un. Utilizouse o maniquí Laerdal Resusci Anne QCPR (Stavanger, Norway) software 2.0.0.14.

A calidade global da RCP foi de 33,3%+32,7 para Pocket CPR, 10,9%+22,72 para CPR Pro e 7,8%+9,2 para Massage cardiaque et DSA. Con ningunha das aplicacións móbiles se conseguen melloras estatisticamente significativas. A porcentaxe de tempo que o reanimador conseguiu manter o ritmo correcto mellorou co uso das tres aplicacións móbiles.

En conclusión, a RCP guiada por aplicacións móbiles non mellorou a calidade global das compresións durante a reanimación, aínda que mellorou a porcentaxe de compresións realizadas a un ritmo correcto.

Limitacións: Este é un estudo con maniquís polo que os resultados poden non ser trasladables á práctica clínica. Os resultados do uso dunha aplicación móbil nunha vítima real ou nun escenario que non sexa simulado poden xerar datos diferentes. Todos os participantes usaron o mesmo teléfono intelixente, isto tamén pode ser un factor limitante xa que non todos os teléfonos teñen os mesmos tamaños e as mesmas prestacións. Polo tanto, os achados teñen que ser tomados con

precaución. A falta de adestramento técnico para a suxeición do teléfono intelixente ou a falta de experiencia dos suxeitos pode ser outro factor limitante.

2. Valoración ABCDE por parte de socorristas: Como manexan un paciente crítico? Un estudo de simulación transversal.

O obxectivo deste estudo foi avaliar a toma de decisións, a capacidade no uso da valoración ABCDE e as habilidades de abordaxe dos socorristas ao se enfrontaren a un caso simulado que require coidados críticos.

Deseñouse un estudo de simulación transversal para avaliar as habilidades e secuencia de valoración ABCDE en 20 socorristas profesionais. Recolléronse variables demográficas, así como variables relacionadas coa habilidade de valoración ABCDE e variables de valoración ABCDE con sistema de seguimento visual (eye-tracking).

A avaliación dos suxeitos foi realizada por tres instrutores en soporte vital básico e soporte vital avanzado así como polo sistema Mobile Eye (Bedford, USA).

Ningún dos participantes do estudo conseguiu completar de forma correcta a valoración primaria. En torno ao 60% das fixacións e do tempo de fixación foi dedicado a zonas de visión importantes para a abordaxe ABCDE, atopándose diferenzas significativas ao comparalo coas zonas de visión sen importancia ($p < 0.008$).

En conclusión, os socorristas deste estudo toman a iniciativa para realizar a valoración ABCDE; con todo, a orde da secuencia é variable e a precisión das habilidades non é a adecuada. A avaliación por expertos coa axuda da tecnoloxía de seguimento pupilar identifica as limitacións na valoración e tratamento, podendo ser unha ferramenta útil para o adestramento de socorristas.

Limitacións: Este é un estudo de simulación polo que unha intervención real podería xerar resultados diferentes. A falta de experiencia dos participantes no uso da simulación podería ser un factor limitante.

3. Aprendizaxe e tratamento da anafilaxia por leigos: Un estudo de simulación utilizando tecnoloxía pupilar

O obxectivo deste estudo foi avaliar dous modelos de formación sobre o recoñecemento e tratamento da anafilaxia para persoas leigas, baseado na valoración de expertos e a tecnoloxía pupilar.

Realizouse un estudo de simulación cuasi-experimental de corte transversal para avaliar a identificación e tratamento da anafilaxia. 50 suxeitos foron randomizados en 4 grupos: 3 usaron diferentes vídeos con contido supervisado por un equipo sanitario e comparouse cunha formación cara a cara nunha consulta pediátrica. Para a avaliación da aprendizaxe deseñouse un escenario de simulación no que se representaba unha vítima de anafilaxia. Utilizouse un dispositivo de rexistro dos movementos oculares e a valoración de expertos para avaliar o desempeño.

A formación pediátrica cara a cara obtivo un mellor e máis rápido recoñecemento da anafilaxia. Os participantes usaron o inxector de adrenalina con maior precisión e menos erros. Con este tipo de formación, os participantes, necesitaron un menor número de fixacións visuais para recoñecer a anafilaxia e tomar a decisión de inxectar a epinefrina.

En conclusión, unha formación cara a cara impartida por un pediatra, mellora o recoñecemento da anafilaxia e a probabilidade da utilización correcta dun inxector. Os vídeos formativos poden ser un recurso útil, pero con gran variabilidade na súa eficacia.

Limitacións: Do mesmo xeito que con outros estudos de simulación os resultados deben considerarse con cautela en caso de vítimas reais.

DISCUSIÓN

O obxectivo principal deste traballo foi a avaliación de diversas situacións simuladas para o estudo e comprensión das habilidades, aprendizaxe e aplicación de técnicas de primeiros auxilios por testemuñas tanto leigas como con obrigación de intervir.

Esta investigación tratou de achegar evidencias sobre as novas tecnoloxías e metodoloxías formativas. No noso coñecemento, esta é a primeira investigación que aborda de forma global o uso da retroalimentación así como a simulación e avaliación con sistema de seguimento visual en persoal non sanitario.

Retroalimentación mediante aplicacións móbiles.

O desempeño inadecuado da RCP é común pero difícil de detectar para os provedores e instrutores (67,68). En teoría, a tecnoloxía podería axudar a abordar este problema avaliando o rendemento da reanimación cardiopulmonar e proporcionando retroalimentación. Neste sentido os dispositivos de retroalimentación que proporcionan información sobre profundidade das compresións, ritmo, reexpansión e posición de mans durante o adestramento melloran o nivel de adquisición de competencias ao final da formación (26,69-89).

As aplicacións móbiles revolucionaron en moitos aspectos a aprendizaxe da RCP (90) ou a activación de testemuñas próximas a accidentes logrando un incremento na realización de RCP por parte de primeiros intervenientes (91-93).

Existen numerosas investigacións sobre a RCP con retroalimentación e a mellora da calidade da reanimación tanto de leigos como profesionais da saúde (26,79,94–96). A tecnoloxía móbil mediante o uso de aplicacións móbiles pretende ofrecer ao primeiro interveniente unha ferramenta que proporcione retroalimentación en tempo real da RCP realizada. O noso estudo investigou a eficacia das compresións torácicas comparando tres aplicacións móbiles.

Os suxeitos deste estudo non melloraron os resultados coa RCP guiada por aplicacións móbiles e, nalgúns casos, mesmo empeoraron. Outros estudos mostraron que diferentes dispositivos que ofrecen retroalimentación aumentan a calidade das compresións torácicas especialmente ritmo e profundidade, cando son utilizados por persoas con formación en RCP (84,97). Os estudantes desta investigación non tiñan formación previa e o seu primeiro contacto coa RCP foi a familiarización inicial coa aplicación móbil antes dos test. A falta de práctica instrumental pode ser un importante factor limitante.

As aplicacións móbiles deste estudo non melloraron a profundidade da compresión, se cadra pola falta de habilidade dos reanimadores, pola falta de precisión da aplicación móbil ou pola incomodidade que pode xerar realizar RCP co teléfono enlazado nas mans. Outros dispositivos que liberan as mans están dispoñibles no mercado e poden ser unha alternativa (98).

A profundidade das compresións foi insuficiente en todos os test realizados, aínda co uso das aplicacións móbiles. Non chegar á profundidade adecuada é un factor concorrente en numerosos estudos con leigos (99). Diversos motivos poden provocar unha carencia na profundidade. Con todo o uso das aplicacións móbiles conseguiron manter a frecuencia de compresións en valores significativamente superiores cando foi comparada cos outros test. Na RCP guiada por dispositivos con retroalimentación, atopouse melloras en canto ao ritmo (100-101). Con todo, elementos simples como música, dispositivos led ou metrónomos poden mellorar esta variable (100) sen a necesidade de ocupar as mans aínda que existen probas de que poden reducir a profundidade da compresión a medida que o suxeito se concentra no ritmo correcto (76,88,89).

O uso dun dispositivo de retroalimentación debe utilizarse cando existen probas estatísticas de validez e fiabilidade como ferramenta de medición (102). Nesta liña, e seguindo as recomendacións da Administración de Alimentos e Drogas dos Estados Unidos (US Food

and Drug Administration) (103), é necesaria unha regulación sobre as aplicacións móbiles médicas de forma que se asegure a súa validez e fiabilidade. Polo que o uso de estratexias dixitais debe ser avaliado de maneira similar a outras intervencións médicas, incluíndo avaliacións formais tales como os 6 dominios da calidade da atención médica identificados polo Instituto de Medicina: seguridade, eficacia, centrada no paciente, oportuna, eficiente e equitativa (104).

En ocasións os mecanismos deseñados para mellorar a RCP, se non se ten a formación, adestramento ou experiencia, non conseguen a súa finalidade. Polo que o uso de dispositivos de retroalimentación durante a RCP só se debe ter en conta como parte dun sistema de atención máis amplo (105) en lugar de como unha intervención illada.

Sistema de seguimento pupilar automático (eye-tracking). Simulación.

A simulación é unha potente ferramenta que permite adestrar e mellorar as habilidades (106) demostrando ser altamente efectiva para o adestramento de eventos críticos (107-108). A simulación permite aos educadores crear experiencias realistas que fomentan a aprendizaxe nunha contorna que non compromete a seguridade do paciente (109), así como adestrar un rango de roles desde a primeira resposta ante a PCR até a dirección dun equipo de RCP.

O adestramento con simulación é unha parte integral do adestramento en emerxencias. Unha revisión sistemática e meta-análise de 182 estudos que incluíu a 16.636 participantes en formación con simulación para a reanimación mostrou unha mellora no coñecemento e no desempeño das habilidades comparadas á formación sen simulación (110).

O uso de métodos válidos, fiables e obxectivos de avaliación de habilidades en situacións críticas é fundamental na formación moderna. A simulación de alta tecnoloxía considérase cada vez máis como unha axuda importante para a aprendizaxe e pode resultar útil na

avaliación do coñecemento, o razoamento clínico e o traballo en equipo (111-112).

De igual modo o sistema de seguimento visual foi proposto como unha ferramenta de avaliación potencial utilizada en múltiples ámbitos e diversos estudos (48-65).

A tecnoloxía de seguimento pupilar permite recoñecer as variables visuais (48,49,53,58,59,62,63,113-115) e establecer patróns que axuden a entender o razoamento clínico implicado na toma de decisións.

Utilizando estas tecnoloxías (simulación e sistema de seguimento pupilar) levamos a cabo as primeiras investigacións nas que se avalía a atención proporcionada en situacións de emerxencia por persoal non sanitario.

O socorrista é a persoa encargada da seguridade (116) prevención e rescate (117) nos ambientes acuáticos. A atención de primeiros auxilios non é unha tarefa habitual xa que representa unha porcentaxe moi baixa do total de accións que realizan os socorristas (118), con todo cando o incidente ocorre, cada segundo conta e débense prestar coidados adecuados e de calidade. Pretendeuse coñecer a capacidade de socorristas no uso da valoración primaria utilizando simulación e o sistema de seguimento visual.

Os socorristas profesionais mostraron diferenzas á hora de recoñecer e tratar a un paciente crítico nunha situación simulada. Todos os participantes do estudo tiñan formación teórica e sabían que era e como se aplicaba a valoración primaria, pero non recibiran formación con simulación e un 55% non utilizara a valoración primaria nunha situación real.

Os socorristas deste estudo avaliaron a A (vía a´rea) (70%) e a B (respiración) (85%) aínda que só o fixeron de forma correcta o 20% en canto a vía aérea e o 25% para a respiración. De feito a valoración da respiración foi realizada correctamente por 5 suxeitos. Só un 40%

avaliou C (circulación). Dos suxeitos que realizaron a avaliación de circulación só 3 tomaron pulso central e 2 pulso periférico. A pesar de que este paso, a valoración de circulación, foi o que máis tempo precisou para levar a cabo a súa valoración (45 seg). Poida que isto fose debido á hemorraxia que presentaba o simulador no membro inferior. A hemorraxia era un factor distractor introducido polos investigadores. Esta hemorraxia era de moi escasa contía, producida por unha erosión. A maior parte de suxeitos deste estudo non se formularon valorar os pulsos nin periférico nin central. Isto podería deberse a que as Guías do Consello Europeo de Resucitación (ERC) (119) así como as Guías da Asociación Americana do Corazón (AHA) (120) de soporte vital básico insisten en que tomar o pulso non é unha medida necesaria para establecer o diagnóstico de parada cardiorrespiratoria. Con todo o simulador non presentaba unha PCR e precisaba valoración da circulación.

A aplicación dun sistema estruturado de valoración converteuse na norma en trauma. Este enfoque para o recoñecemento precoz e o tratamento de lesións potencialmente mortais foi practicado en cursos de trauma durante décadas (121,122). No estudo de Olgers et al. no que investigaron o uso do enfoque ABCDE por médicos dun servizo de urxencias observaron que este enfoque foi utilizado no 26% dos pacientes. Cando a abordaxe secuencial ABCDE foi utilizada fíxose con altas puntuacións (83%). O motivo polo que os médicos decidiron non utilizar este enfoque de valoración foi pola impresión clínica xeral, os signos vitais rexistrados por enfermería ou que o motivo da consulta non suxire paciente inestable (123). Noutro estudo realizado nun servizo de urxencias hospitalarias atopáronse que o 52% dos pacientes foron avaliados coa sistemática ABCDE sendo avaliados de forma completa e con precisión o 17% (124).

Á vista dos nosos resultados parece que os socorristas da nosa investigación atópanse por baixo en canto a cumprimento do protocolo ABCDE. Con respecto ás fixacións visuais os socorristas manteñen unha adecuada atención e fixación, é dicir están centrados

en mirar. En torno ao 60% das fixacións e do tempo de fixacións visuais foi dedicado a zonas de visión importantes para a abordaxe ABCDE. Isto é independente ás decisións tomadas en cada momento. Pode estar a centrar a súa mirada pero non saber as decisións para tomar.

Seguimento pupilar automático. Simulación. Paciente estandarizado.

Os pacientes estandarizados son actores que están adestrados para retratar aos pacientes consistentemente en ocasións repetidas (111). As interaccións con pacientes estandarizados poden adaptarse para cumprir obxectivos educativos específicos de modo que os actores que representan aos pacientes poden cualificar o desempeño do interveniente na simulación. As avaliacións estruturadas co uso de pacientes estandarizados son tan fiables como as cualificacións dos encontros directamente observados con pacientes reais (125-127). Mediante o uso de paciente estándar e o sistema de seguimento pupilar automático avaliamos dous modelos de formación (vídeo vs. cara a cara ou presencial) e a súa aplicación nun caso simulado de anafilaxia.

Diferentes sistemas de formación mediante vídeo reportaron éxito no ensino de técnicas relacionadas coas emerxencias (128,129). No noso estudo, a formación tradicional cara a cara proporcionada por persoal experto obtivo mellores resultados que a formación en vídeo. Contrariamente diversos estudos sobre RCP mostraran bos resultados para a formación mediante vídeo (128,130).

Os suxeitos do grupo que recibiu a formación cara a cara ou presencial con un instructor son os segundos máis rápidos á hora de ter o inxector na man e os máis rápidos á hora de utilizar e administrar a epinefrina. O grupo "cara a cara" ofrece o tratamento adecuado á anafilaxia en 36±21,5 segundos desde o inicio do escenario. Johnston, EB et al (131) atoparon nun estudo realizado con residentes de anestesia nun simulación intraoperatoria que o tempo medio de diagnóstico da anafilaxia foi de 7,6±2,4 min e o tempo para

administrar a epinefrina 6,5 ± 2,1 minutos. Necesítase unha maior énfase no pronto recoñecemento e tratamento apropiado da anafilaxia por profesionais da saúde (132).

O estudo de Arga, M et al (133) no que avaliaron a habilidade de médicos no uso de inxectores de epinefrina antes e despois de recibir formación teórico-práctica viron que os erros no uso dos autoinxectores poden estar relacionados co seu deseño. No noso estudo observamos que o inadecuado manexo do autoinxector é máis frecuente nos grupos formados mediante vídeo. O grupo que recibiu a formación cara a cara non cometeu ningún erro na súa manipulación.

Á vista dos resultados parece que no noso estudo os erros na manipulación do inxector están máis relacionados coa formación recibida que co propio deseño do autoinxector. No estudo de Grouhi, M. et al (134) no que se avaliaron as habilidades de médicos, enfermeiros e farmacéuticos no uso de autoinxectores de epinefrina, a maioría de participantes un 75% non demostraron a capacidade de usar o dispositivo de maneira adecuada. No noso estudo as porcentaxes varían dun 100% de uso non adecuado a un 61,5% dependendo da formación recibida.

Os suxeitos que recibiron a formación presencial recoñecen de forma máis rápida e con menores fixacións visuais os síntomas propios da anafilaxia e teñen máis probabilidade de administrar con eficacia o tratamento da anafilaxia. Estes suxeitos realizan menos fixacións visuais nos signos da anafilaxia que o resto de grupos. Isto pode deberse a que debido á súa formación recoñecen de forma máis rápida os signos propios de anafilaxia polo que non precisan tantas fixacións. En cambio os dous grupos que máis fixacións visuais realizan son os que peor tratamento ofrecen.

Os expertos, en comparación cos non expertos, presentan fixacións de duración máis curta, máis fixacións en áreas relevantes para as tarefas e menos fixacións en áreas redundantes (135). Existen diferentes patróns visuais en profesionais experimentados e novatos de modo

que a identificación das áreas da mirada e o aumento das fixacións nos expertos permite a demostración destes aos novatos o que podería facilitar a aprendizaxe e a habilidade (47). A mirada e as fixacións poden adestrarse. En campos como no deporte demostraron melloras no rendemento (136–138).

O recoñecemento dos patróns visuais pode axudar a entender o razoamento implicado na toma de decisións. O uso da simulación xunto ao coñecemento obtido a través de dispositivos de seguimento da mirada pode contribuír á optimización da formación e á mellora dos resultados na prestación dos primeiros auxilios.

LIMITACIÓNS

Todas as investigacións realizadas foron con simulación, polo que non podemos confirmar se estes resultados son xeneralizables ao ambiente clínico real.

CONCLUSIÓNS

1. A simulación e a tecnoloxía de seguimento pupilar automático (eye-tracking) son ferramentas útiles e fiables para a avaliación do desempeño en situación de emerxencia.
2. As aplicacións móbiles non supoñen unha axuda para mellorar a calidade das compresións.
3. Realizar RCP cun teléfono móbil entre as mans non interfire coa calidade da RCP.
4. Os socorristas toman a iniciativa para realizar a avaliación primaria con todo a orde da secuencia é variable e a precisión das habilidades non é a adecuada.
5. Os socorristas manteñen unha adecuada atención e fixación durante a situación simulada. En torno ao 60% das fixacións e do tempo de fixacións visuais foi dedicado a zonas de visión importantes para a abordaxe ABCDE.

6. A formación presencial con un instructor é un método máis eficaz que a formación mediante vídeo para o recoñecemento e tratamento adecuado da anafilaxia.
7. O grupo de profesores que recibiu a formación presencial (“ cara a cara” con un instructor), en comparación cos outros grupos, recoñeceu de forma máis rápida e con menores fixacións visuais a anafilaxia.
8. A formación presencial con un instructor xerou un tratamento da anafilaxia máis rápido e correcto en comparación cos outros grupos.

ABSTRACT

New strategies in emergency training

INTRODUCTION

A high number of prehospital deaths due to trauma occur with injuries that are potentially recoverable, although first aid intervention is infrequent (1-4).

This first attention goes through the recognition of the emergency and the alert to the emergency services. This initial alert is carried out correctly in most cases, but is associated, in the event that it is carried out incorrectly, with a lower probability of treatment by emergency medical services and worse survival outcomes (5).

The time that elapses from the onset of symptoms, in the case of a possible myocardial infarction, until seeking attention has not improved significantly (6,7) despite the advances in its treatment.

Similarly, in the case of stroke, there are still difficulties in recognizing symptoms and seeking treatment by patients and families (8–13). In this regard, despite public education initiatives and clinical practice recommendations, there are still important gaps in the timely identification of symptoms and the initiation of first aid (14–16).

Most trauma deaths occur at the scene of the incident, often before the arrival of emergency medical services (EMS) (17,18). Between 6 and 20% of prehospital deaths due to trauma occur with injuries that are potentially recoverable (3,19,20). After a life-threatening incident,

witnesses have the opportunity to initiate the necessary care. However, first aid intervention by witnesses is rare and very variable, ranging from 10.7% to 65, providing first aid incorrectly in up to 83.7% of cases (21).

In this type of situation, witnesses with little or no training can be an essential link in the "survival chain" of critical health emergencies (22) by applying first aid on-site and immediately.

Teaching-learning process of skills by adults.

Adult learning presents challenges that are not observed in the young student population. Adults have experiences, personality traits, relationship patterns that determine their actions (23). Adults like that their learning focuses on problems and has practical applicability. They learn best when they can immediately apply what they have learned (24).

Traditional teaching methods based on expository models are not effective in adult education. The estimated half-life of professional knowledge acquired through formal education can be as little as 2 to 2.5 years (25). In the case of activities that require both formal knowledge and a basic set of skills, such as life support, retention can be as little as 6 weeks (26–31).

It is known that CPR skills deteriorate in a short time after training (26-32), so using evidence-based educational principles is essential for training optimization.

Evaluation of competencies in emergencies.

The success of emergency care requires cognitive, psychomotor and behavioral skills. There is a growing emphasis on focusing student training and evaluation on mastery learning (33), the acquisition of the McGaghie Master's Degree (34) or at the highest levels of Miller's description (35).

The evaluation of these skill levels requires the use of appropriate evaluation methods.

The skills evaluation is a challenge in itself because not all evaluation methods are useful for different levels of competence (36). A limitation of the evaluation is that it may not demonstrate real future performance. The evidence that the evaluation protects the public from poor quality care is both indirect and scarce; It consists of a few studies that show correlations between assessment programs that use multiple methods and relatively rudimentary estimates of quality, such as diagnostic tests, prescription, and remission patterns (37).

Correlating the evaluation with future performance is complex, not only due to the evaluation process itself but to the limitation of training and its relationship with future performance.

Innovative strategies in emergency training.

The World Health Organization (WHO), numerous international scientific societies as well as various investigations have considered the potential impact of the use of digital technologies as a mechanism to act on health (32,38-45).

New technologies have the potential to transform not only training and evaluation but the provision of health services (table 2).

Visual tracking system and its possible role in adult training (Eye-tracking).

The eye-tracking system is a well established concept since it was first used in 1950 to study the visual behavior of pilots (46). This system has a device that focuses a camera towards the subject's eye so that pupillary movements can be recorded for later analysis.

Eye monitoring measures the behavior of the gaze during the execution of the task, which allows knowing data on decision making.

The development of valid, reliable methods and skills assessment objectives is essential for training (47). In this sense, the eye-tracking system is a method used for evaluation (48-62) and can measure different skill levels (48-50,52,54,55,58,60,63-65).

Opportunities that new technologies offer to train in the emergency field.

In 2003, Chamberlain and Hazinski (66) estimated the functioning of the chain of survival at the local level, which depends primarily on laypeople, and established an ideal to be achieved. This ideal would have the potential to save the lives of patients, victims of an emergency CRA situation.

The American Heart Association, in the year 2018, in the document "Educational strategies to improve the results of cardiac arrest" (42) indicates that the formula for survival depends fundamentally on educational efficiency and the local implementation of training programs, these two factors being, determinants in survival.

These survival formulas show the potential that appropriate interventions on first responders may have on survival in an emergency situation.

The low participation of first responders in an emergency situation offers an opportunity for improvement. Efficient training and evaluation, consistent with scientific evidence as well as the use and exploitation of new technologies have the potential to save thousands of lives of victims of emergency situations (45). In this sense, the use of simulation and the eye-tracking system can be useful technologies to achieve these objectives.

HYPOTHESIS

- Simulation and the eye-tracking system are useful tools to evaluate and know the degree of performance in simulated situations.
- Mobile applications with real-time feedback improve the quality of CPR performed by laypeople.
- Performing CPR by laypeople with a mobile phone in their hands decreases the quality of CPR.
- Professional lifeguards with theoretical training in primary assessment perform, in a simulated situation, primary assessment poorly.
- During simulation with a critical patient, professional lifeguards focus their attention on the patient.
- Classroom training is more effective for the recognition and treatment of anaphylaxis than video training.
- Faced with a simulated case, teachers will focus their visual fixations on the victim of anaphylaxis.
- After receiving video training or face-to-face training, teachers will perform an adequate treatment of anaphylaxis.

OBJECTIVES

The main and secondary objectives of this research are;

1. Assess the use of simulation and automatic pupil tracking technology (eye-tracking) as a method of performance evaluation in various emergency situations.
2. Evaluate the quality of cardiopulmonary resuscitation (CPR) of non-experts guided by a mobile application (APP) with real-time feedback.

2.1. Evaluate whether performing CPR with a mobile phone in your hands interferes with the quality of resuscitation.

3. Assess decision making and the degree of performance in primary assessment in a simulated situation by first responders.

3.1. Know the visual pattern of first responders in the assessment of a simulated critical situation.

4. Compare in a simulated environment the usefulness of two training models (video vs. face-to-face) for the recognition and treatment of anaphylaxis.

4.1. Know the visual pattern of teachers in the resolution of a simulation with a patient with anaphylaxis.

4.2. Determine the level of competence of teachers in a simulated anaphylaxis situation.

RESULTS

This thesis follows the modality of a compendium of articles. Therefore the results are presented as research articles.

1. Evaluation of the thoracic compression technique using APPs. Do they help or hinder cardiopulmonary resuscitation?

The objective of this study was to evaluate the quality of cardiopulmonary resuscitation (CPR) of non-experts guided by a mobile application with real-time feedback.

A quasi-experimental cross-sectional study was conducted. A sample of 113 Nursing students without experience or training in CPR participated in the study. Three hands-free CPR tests were performed with continuous compressions: 1) CPR without a device, 2) CPR with the phone off, 3) APP-guided CPR. Three different applications were randomized [Pocket CPR®, CPR Pro® and Massage cardiaque et

DSA®]. The three tests were performed consecutively, randomized and separated 30 minutes between each one. The mannequin Laerdal Resusci Anne QCPR (Stavanger, Norway) software 2.0.0.14 was used.

The overall quality of the CPR was 33.3% + 32.7 for Pocket CPR, 10.9% + 22.72 for CPR Pro and 7.8% + 9.2 for Massage cardiaque et DSA. With none of the APPs, statistically, significant improvements are achieved. The percentage of time that the rescuer managed to maintain the correct rhythm improved with the use of the three APPs.

In conclusion, CPR guided by APPs did not improve the overall quality of compressions during resuscitation, although the percentage of compressions performed at a correct rate improved.

Limitations: This is a study with dummies so the results may not be transferable to clinical practice. The results of using an APP in a real victim or in a scenario that is not simulated can generate different data. All participants used the same Smartphone, this can also be a limiting factor since not all phones have the same sizes and the same features, therefore the findings have to be taken with caution. The lack of technical training for the subjection of the Smartphone or the lack of experience of the subjects can be another limiting factor.

2. **ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross-sectional simulation study.**

The objective of this study was to evaluate decision-making, the ability to use the ABCDE assessment and the approach skills of first responders when facing a simulated case that requires critical care.

A cross-sectional simulation study was designed to assess ABCDE skills and assessment sequence in 20 professional lifeguards. Demographic variables were collected, as well as variables related to

ABCDE assessment ability and ABCDE assessment variables with the eye-tracking system.

The subjects were evaluated by three BLS and ALS instructors as well as by the Mobile Eye system (Bedford, USA).

None of the study participants successfully completed the primary assessment. Around 60% of fixations and fixation time was dedicated to areas of vision important for the ABCDE approach, finding significant differences when compared with unimportant areas of vision ($p < 0.008$).

In conclusion, the lifeguards of this study take the initiative to perform the ABCDE assessment, however, the sequence order is variable and the accuracy of the skills is not adequate. Expert evaluation with the help of eye-tracking technology identifies limitations in assessment and treatment and can be a useful tool for training lifeguards.

Limitations: This is a simulation study so a real intervention could generate different results. The lack of experience of the participants in the use of simulation could be a limiting factor.

3. Learning and treatment of anaphylaxis by laypeople: A simulation study using pupilar technology

The objective of this study was to evaluate two training models on the recognition and treatment of anaphylaxis for inexperienced people, based on the assessment of experts and pupil technology.

A quasi-experimental cross-sectional simulation study was conducted to evaluate the identification and treatment of anaphylaxis. 50 subjects were randomized into 4 groups: 3 used different videos with content supervised by health staff and was compared with face-to-face training in pediatric consultation. For the evaluation of learning, a simulation scenario was designed in which a victim of anaphylaxis was

represented. An eye movement recording device and expert assessment were used to assess performance.

Pediatric face-to-face training gained better and faster recognition of anaphylaxis. Participants used the adrenaline injector with greater precision and fewer errors. With this type of training, participants needed a smaller number of visual fixations to recognize anaphylaxis and make the decision to inject epinephrine.

In conclusion, a face-to-face training given by a pediatrician improves the recognition of anaphylaxis and the probability of the correct use of an injector. Training videos can be a useful resource, but with great variability in their effectiveness.

Limitations: As with other simulation studies, the results should be considered with caution in the case of real victims.

DISCUSSION

The main objective of this doctoral thesis work, through a compendium of articles, was the evaluation of various simulated situations for the study and understanding of the skills, learning, and application of first aid techniques by both lay witnesses and with the obligation to intervene.

This research has tried to provide evidence on new technologies and training methodologies. To our knowledge, this is the first research that deals globally with the use of feedback as well as simulation and evaluation with eye-tracking in non-health personnel.

Feedback through mobile applications.

Improper performance of CPR is common but difficult to detect for providers and instructors (67,68). In theory, technology could help address this problem by evaluating the performance of cardiopulmonary resuscitation and providing feedback. In this sense,

the feedback devices that provide information on compression depth, rhythm, re-expansion, and hand position during training improve the level of competence acquisition at the end of the training (26,69-89).

Mobile applications have revolutionized in many aspects the learning of CPR (90) or the activation of witnesses close to accidents, achieving an increase in CPR performance by first responders (91-93).

There is numerous research on CPR with feedback and the improvement of the quality of resuscitation of both inexperienced and health professionals (26,79,94–96)... Mobile technology through the use of APPs aims to offer the first participant a tool that provides real-time feedback of CPR performed. Our study investigated the efficacy of chest compressions by comparing three APPs.

The subjects of this study did not improve the results with CPR guided by APP and in some cases even worsened. Other studies have shown that different devices that offer feedback increase the quality of chest compressions, especially rhythm and depth when used by people with CPR training (84,97). The students of this research had no previous training and their first contact with the CPR was the initial familiarization with the APP before the tests. The lack of instrumental practice can be an important limiting factor.

The APPs in this study did not improve the depth of compression, perhaps due to the lack of ability of the resuscitators, due to the lack of precision of the APP or due to the discomfort that CPR can generate with the telephone linked in the hands. Other devices that release the hands are available in the market and maybe an alternative (98).

The depth of the compressions has been insufficient in all the tests performed, even with the use of APPs. Not reaching the right depth is a concurrent factor in numerous studies with inexperienced (99). Various reasons can cause a lack of depth. However, the use of APPs has managed to maintain the frequency of compressions at

significantly higher values when compared to the other tests. In CPR guided by devices with feedback, improvements in rhythm have been found (100,101). However, simple elements such as music, led devices or metronomes can improve this variable (100) without the need to occupy the hands although there is evidence that they can reduce the depth of compression as the subject focuses on the correct rhythm (76,88,89).

The use of a feedback device should be used when there are statistical tests of validity and reliability as a measuring tool (102). In this line and following the recommendations of the US Food and Drug Administration (FDA) (103) a regulation on medical APPs is necessary in order to ensure its validity and reliability. Therefore, the use of digital strategies should be evaluated in a similar way to other medical interventions, including formal evaluations such as the 6 domains of the quality of medical care identified by the Institute of Medicine: safety, efficacy, patient-centered, timely, efficient and equitable (104).

Sometimes mechanisms designed to improve CPR, if education, training or experience are not acquired, do not achieve their purpose. Therefore, the use of feedback devices during CPR should only be considered as part of a broader system of care (105) rather than as an isolated intervention.

Eye tracking. Simulation.

A simulation is a powerful tool that allows to train and improve skills having (106) proved highly effective for training critical events (107,108). The simulation allows educators to create realistic experiences that foster learning in an environment that does not compromise patient safety (109), as well as train a range of roles from the first response to the CRA to the direction of a CPR team.

Simulation training is an integral part of emergency training. A systematic review and meta-analysis of 182 studies that included 16,636 participants in simulation training for resuscitation showed an

improvement in knowledge and performance of skills compared to training without simulation (110).

The use of valid, reliable methods and skills assessment objectives in critical situations is essential in modern training. High-tech simulation is increasingly considered an important aid for learning and can be useful in the assessment of the knowledge, clinical reasoning, and teamwork (111,112).

Similarly, the eye-tracking system has been proposed as a potential assessment tool used in multiple fields and various studies (48-65).

Eye-tracking technology allows us to recognize visual variables (48,49,53,58,59,62,63,113-115) and establish patterns that help to understand the clinical reasoning involved in decision making.

Using these technologies (simulation and eye-tracking) we have carried out the first investigations in which the care provided in emergency situations by non-health personnel is evaluated.

The lifeguard is the person in charge of safety (116) prevention and rescue (117) in aquatic environments. First aid care is not a usual task since it represents a very low percentage of the total actions taken by first responders (118), however, when the incident occurs, every second count and adequate and quality care should be provided. It has been tried to know the capacity of lifeguards in the use of the primary assessment using simulation and the eye-tracking system.

Professional lifeguards showed differences in recognizing and treating a critical patient in a simulated situation. All study participants had theoretical training and knew what it was and how the primary assessment was applied but had not received training with simulation and 55% had not used the primary assessment in a real situation.

Lifeguards in this study evaluated Airway (70%) and Breathing (85%) although only Airway 20% and Breathing 25% did so correctly. In fact, the assessment of Breathing was correctly performed by 5

subjects. Only 40% evaluated Circulation. Of the subjects who performed the Circulation evaluation, only 3 took a central pulse and 2 peripheral pulse. In spite of this, the Circulation valuation was the one that required the most time to carry out its valuation (45sec). This may be due to the bleeding presented by the simulator in the lower limb. Hemorrhage was a distracting factor introduced by the researchers. This was of a very small amount, produced by erosion. The majority of subjects in this study did not consider assessing the peripheral or central pulses. This could be because the Guidelines of the European Resuscitation Council (119), as well as the Guidelines of the American Heart Association (120) of basic life support, insist that taking the pulse is not a necessary measure to establish the diagnosis of cardiorespiratory arrest. However, the simulator did not present a CRA and required a Circulation assessment.

The application of a structured system of assessment has become the norm in trauma. This approach to early recognition and treatment of life-threatening injuries has been trained in trauma courses for decades (121,122). In the study by Olgers et al. in which they investigated the use of the ABCDE approach by doctors from an emergency department, they observed that this approach was used in 26% of the patients. When ABCDE approach was used it was done with high scores (83%). The reason why the doctors decided not to use this assessment approach was due to the general clinical impression, the vital signs registered by nursing or that the reason for the consultation does not suggest an unstable patient (123). In another study conducted in a hospital emergency department, it was found that 52% of the patients were evaluated with the ABCDE approach, and 17% were fully and accurately evaluated (124).

In view of our results, it seems that the first responders of our research are below in terms of compliance with the ABCDE protocol. With respect to visual fixations, lifeguards maintain adequate attention and fixation, that is, they are focused on looking. Around 60% of the fixations and the time of visual fixations were dedicated to areas of

vision important for the ABCDE approach. This is independent of the decisions made at all times. He may be focusing his gaze but not knowing the decisions to be made.

Eye tracking. Simulation. Standardized patient.

Standardized patients are actors who are trained to portray patients consistently on repeated occasions (111). Interactions with standardized patients can be adapted to meet specific educational objectives so that the actors who represent the patients can rate the performance of the intervener in the simulation. Structured evaluations with the use of standardized patients are as reliable as the qualifications of the meetings directly observed with real patients (125-127). Through the use of a standard patient and the eye-tracking system we evaluate two training models (video vs. Face to face) and their application in a simulated case of anaphylaxis.

Different video training systems have reported success in teaching techniques related to emergencies (128,129). In our study, traditional face-to-face training provided by the expert staff has obtained better results than video training. On the contrary, several studies on CPR had shown good results for video training (128,130).

The subjects of the group that has received the "face to face" training are the second fastest at the time of having the injector in hand and the fastest at the time of using and administering the epinephrine. The "face to face" group offers adequate treatment for anaphylaxis in 36 ± 21.5 seconds from the start of the scenario. Johnston EB et al (131) found in a study conducted with anesthesia residents in an intraoperative simulation that the average diagnosis time of anaphylaxis was 7.6 ± 2.4 minutes and the time to administer epinephrine 6.5 ± 2.1 minutes (132).

The study by Arga, M et al (133) in which they evaluated the ability of doctors to use epinephrine injectors before and after receiving theoretical-practical training, found that errors in the use of auto-

injectors may be related to the design of the same. In our study, we have observed that the improper handling of the autoinjector is more frequent in the groups formed by video. The group that received the face to face training did not make any mistakes in its manipulation.

In view of the results, it seems that in our study the errors in the manipulation of the injector are more related to the training received than to the design of the autoinjector itself. In the study by Grouhi, M. et al (134) in which the skills of doctors, nurses, and pharmacists in the use of epinephrine auto-injectors were evaluated, the majority of participants 75% did not demonstrate the ability to use the device properly. In our study, the percentages vary from 100% of inappropriate use to 61.5% depending on the training received.

Subjects who have received ("face-to-face") training recognize the symptoms of anaphylaxis more quickly and with less visual fixations and are more likely to effectively administer anaphylaxis treatment. These subjects make less visual fixations on the signs of anaphylaxis than the other groups. This may be due to the fact that due to their formation they recognize the signs of anaphylaxis more quickly so they do not require so many fixations.

On the other hand, the two groups that make the most visual fixations are the ones that offer the worst treatment.

Experts, compared to non-experts, have shorter duration fixations, more fixations in areas relevant to tasks and fewer fixations in redundant areas (135). There are different visual patterns in professionals with experience and novices so that the identification of the areas of the gaze and the increase of the fixations in the experts allows the demonstration of these to the novices which could facilitate the learning and the skill (47). Looks and fixings can be trained. In fields such as sports have shown improvements in performance (136–138).

The recognition of visual patterns can help to understand the reasoning involved in decision making. The use of simulation together

with the knowledge obtained through gaze tracking devices can contribute to the optimization of training and the improvement of results in the provision of first aid.

LIMITATIONS

All the investigations have been simulated, so we cannot confirm whether these results are generalizable to the real clinical environment.

CONCLUSIONS

1. Simulation and pupil tracking technology (eye-tracking) are useful and reliable tools for assessing emergency performance.
2. APPs do not help to improve the quality of compressions.
3. Performing CPR with a mobile phone in your hands does not interfere with the quality of CPR.
4. The first responders take the initiative to carry out the primary evaluation, however, the sequence order is variable and the accuracy of the skills is not adequate.
5. The lifeguards maintain adequate attention and fixation during the simulated situation. Around 60% of the fixations and the time of visual fixations were dedicated to areas of vision important for the ABCDE approach.
6. Face-to-face training is a more effective method than video training for the recognition and proper treatment of anaphylaxis.
7. The group of teachers who received face-to-face training ("face to face"), compared with other groups, recognized anaphylaxis more quickly and with less visual fixations.
8. Face-to-face training generated faster and more correct anaphylaxis treatment compared to the other groups.

INTRODUCTION

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DE SANTIAGO
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1. INTRODUCTION

1.1. Outpatient emergency treatment. An approach to the current state of the art.

A high number of prehospital deaths due to trauma occur with injuries that are potentially recoverable, although first aid intervention is infrequent (1-4).

"First Aid" refers to the initial attention given to the acute manifestation of any disease or injury in which the time that elapses from the identification of the problem to the treatment must be rapid in order to reduce suffering, morbidity or mortality (139).

This first basic care goes through the recognition of the emergency and the alert to the emergency services. This initial alert is carried out correctly in most cases but is associated, in the event that it is carried out incorrectly, with a lower probability of treatment by the EMS and worse survival results (5).

The time that elapses from the onset of symptoms, in the case of a possible myocardial infarction, until seeking attention has not improved significantly (6,7) despite the advances in its treatment.

Similarly, in the case of stroke, there are still difficulties in recognizing symptoms and seeking treatment by patients and families (8–13). In this regard, despite public education initiatives and clinical practice recommendations, there are still important gaps in the timely identification of symptoms and the initiation of first aid (14–16).

Most trauma deaths occur at the scene of the incident, often before the arrival of Emergency Medical Services (EMS) (17,18). Between 6 and 20% of prehospital deaths due to trauma occur with injuries that are potentially recoverable (3) (19,20). After a life-threatening incident, witnesses have the opportunity to initiate the necessary care. However, first aid intervention by witnesses is rare and very variable, ranging from 10.7% to 65, providing first aid incorrectly in up to 83.7% of cases (21).

In this type of situation, witnesses with little or no training can be an essential link in the "survival chain" of critical health emergencies (22) by applying first aid on-site and immediately.

In a recent review, interesting results were presented suggesting that passers-by first aid resulted in a possible survival improvement of 1.8-5%, but the frequency and quality of first aid provided varied greatly (21).

The worst manifestation of the emergency is cardiorespiratory arrest (CRA). Cardiopulmonary resuscitation (CPR) and early defibrillation are fundamental links in the survival chain (140). It is well established that CPR performed by pedestrians is critical for survival in out-hospital cardiac arrest (32) and that high-quality cardiopulmonary resuscitation is associated with better survival outcomes in case of cardiac arrest (141).

Despite continuous advances in resuscitation, survival rates for cardiac arrests continue to be lower than optimal in both hospital and outpatient settings (141). As an example, studies of out-hospital cardiac arrest (OHCA) have noted delays in the onset of cardiopulmonary resuscitation by passersby (142).

Poor performance in CPR is associated with reduced survival (32) and there is evidence that inexperienced training has improved survival at 30 days and one year (143,144).

Although millions of first intervenors and people with an obligation to intervene receive resuscitation training, every year, there are significant deficiencies in providing optimal clinical care for people with cardiac arrest. Educational activities are not consistently achieving the expected results, with a significant decline in skills within a few months of the learning activity (45,145).

Despite the efforts, there is still a reluctance to perform CPR (146). This provides an opportunity to raise awareness of the need for emergency action by first responders at the scene of the incident (147).

There is evidence that training laypeople in BLS are effective in improving the number of people willing to undertake BLS in a real situation (148–150). And it is known that although first aid training is not up to date, it is a factor that allows providing this first intervention (151).

The simple fact of ensuring that CRA victims receive attention according to the current state of scientific knowledge has the potential to save thousands of lives each year in the United States and other developed countries (45) make it necessary to seize this opportunity.

1.2. Teaching-learning process of skills by adults

Adult learning presents challenges that are not observed in the young student population. Adults have experiences, personality traits, relationship patterns that determine their actions (23). Adults like their learning to focus on problems and have practical applicability. They learn best when they can immediately apply what they have learned (24).

Traditional teaching methods based on expository models are not effective in adult education. The estimated half-life of professional knowledge acquired through formal education can be as little as 2 to

2.5 years (25). In the case of activities that require both formal knowledge and a basic set of skills, such as life support, retention can be as little as 6 weeks (26–31).

It is known that CPR skills deteriorate in a short time after training (26-32) so using evidence-based educational principles is essential for training optimization. The American Heart Association (AHA) has used these learning theories resulting in substantial changes in its formation (152).

Experiential Learning.

An essential component of emergency training is experiential learning. It is based on learning through experience. Defined as "learning through reflection on doing." This type of learning provides a 4-stage framework necessary to consolidate knowledge: “concrete experience, reflexive observation, abstract conceptualization, and active experimentation” (153).

Domain learning.

Currently, in emergency training, students are looking to achieve the highest standards for all educational outcomes rather than simply meeting the minimum standard (154–157). These are known as domain learning (33). Although that is not a new educational concept, it represents a change in the way it is formed in emergencies.

There is substantial evidence to suggest that domain learning is the key to retaining skills and preventing the rapid decline of skills and knowledge after simulation-based learning (154–157).

Competition / Master.

Competence in medicine is defined as “habitual and sensible use of communication, knowledge, technical skills, clinical reasoning, emotions, values and reflection in daily practice for the benefit of the people and communities to which attends." (158). It is true that the level of competence to be achieved by the general population has

nothing to do with the level of competence of health professionals but competition should be understood not as an achievement, but rather a habit of lifelong learning (159).

The competition is contextual, reflecting the relationship between a person's abilities and the tasks that he must perform in a particular situation in the real world (160).

McGaghie (34) talks about different levels of competition acquisition. The highest level that can be acquired is mastery. Describe 7 complementary characteristics:

- Baseline or diagnostic tests;
- Clear learning objectives, sequenced as units, generally in increasing difficulty;
- Participation in educational activities (for example, deliberate practice of skills, calculations, interpretation of data, reading) focused on achieving the objectives;
- A minimum standard established to pass (for example, the test score) for each educational unit;
- Formative tests to evaluate the completion of the unit to a pre-established minimum standard for the domain;
- Advance to the next educational unit if the measured achievement is equal to or higher than the mastery standard; Y
- Continue the practice or study in an educational unit until the level of mastery is reached.

Deliberate practice.

First described by Ericsson et al (161) in 1993, deliberate practice "includes activities that have been specially designed to improve the current level of performance" in which weaknesses are systematically identified and addressed to move to the next level.

They emphasize that repetition is not enough; rather, the repetition must be accompanied by feedback aimed at the weaknesses and accompanied by the assignment of specific exercises so that the

individual addresses them between sessions with the coach or instructor. Reflection after practice is essential since it avoids automaticity and helps improve performance.

Deliberate fast cycle practice.

Hunt et al introduced a variant of deliberate practice called deliberate rapid cycle practice. This recognizes the need to quickly reach an established level of mastery and experience. It is based on the high-risk nature of certain clinical skills related to time-dependent emergencies such as CRA (162).

Key features of the instructional design include a simulation of baseline formative assessment, followed by interruptions when errors are observed, objective feedback based on data, multiple opportunities to rewind and repeat until the concept is mastered, and then an escalation of the difficulty.

Deliberate rapid cycle practice has been associated with good results (162) with shorter training times, along with a decrease in impairment of skills compared to standard simulation approaches (162–166).

Informative session with constructive criticism (Debriefing).

Debriefing is a fundamental learning strategy when it is part of clinical simulation experience. Debriefing is an essential component of simulation-based learning and is an effective teaching strategy and learning method to consolidate students' knowledge and skills (167).

Historically, debriefing began in the army. The term was used to describe the report that individuals made when returning from a mission (168). This story was analyzed with subjectivity and was used to develop strategies for other missions or exercises.

Debriefing sessions are discussions that provide an opportunity for students to discuss with each other what they have learned after performing a simulation. It is useful for processing information,

learning and for students to wonder what they achieved. These sessions are important for students as they provide constructive criticism and an opportunity for reflection and for personal and professional development (167).

Debriefing is itself a teaching strategy. Informative sessions facilitate the use of therapeutic communication skills, address students' emotions and affirm feelings as an integral component of the teaching-learning process (169).

Despite the many approaches to the debriefing session, there are a number of structural elements common to most. Lederman identified seven common structural elements involved in the debriefing process (Table 1) (170).

Table 1: Common elements involved in the debriefing process (170)

Interrogation
Participants
Experience
Experience Impact
Collection
Report
Time

Strategies.

These principles can be used in emergency training to create effective and efficient training programs.

A review and meta-analysis showed that simulation with the deliberate practice for domain learning is superior to traditional clinical education in the acquisition of clinical skills (171).

Including basic educational principles such as deliberate practice, feedback and Debriefing should support the participants' development towards mastery (152,172,173).

1.3. The evaluation of competencies in emergencies.

The success of emergency care requires cognitive, psychomotor and behavioral skills. There is an increasing emphasis on focusing student training and evaluation on mastery learning (33), acquiring the McGaghie Master's Degree (34) or at the highest levels of Miller's description (35).

In 1990 Miller establishes a model for the evaluation of competencies establishing the stages that must be acquired until developing competence. This model establishes 4 stages, the first two related to cognitive areas and the upper two with behavioral areas.

- Known. First level of the pyramid, know the subject

- Know how to do it. The second level of the pyramid, describe how it would be done.

Both work at the cognitive level. This knowledge is contextualized and includes skills such as decision making and critical reasoning.

- Show how it would be done. Third level, behavioral, demonstrate in a simulation how it would be done. It includes behavior (skills). The context of competition application is not real is done in simulated environments.

- Do. Fourth level, behavioral, act in a real situation. Demonstrated competence in real professional situations or contexts.

The evaluation of these skill levels requires the use of appropriate evaluation methods.

Van der Vleuten (174) describes five criteria to determine the usefulness of a particular evaluation method:

- Reliability, the degree to which the measurement is accurate and reproducible.
- Validity, if the evaluation measures what it intends to measure.
- Impact on future learning and practice.
- Acceptability by students and faculty.
- Cost; for the individual student, the institution and society in general.

Evaluation is an essential part of the educational process. The evaluation focuses on the improvement of local (175) quality and can be classified according to its objective in formative or cumulative evaluation.

Formative evaluation guides future learning, provides security, promotes reflection and forms values. The cumulative evaluation allows making a general judgment about the competence, the aptitude for the practice or the qualification to ascend to higher levels of responsibility. Formative assessments provide benchmarks to guide the student who approaches a relatively unstructured body of knowledge. They can reinforce students' intrinsic motivation to learn and inspire them to set higher standards for themselves (176). Although cumulative assessments are intended to provide self-regulation and professional responsibility, they can also act as a barrier to practice or additional training (177).

However, since students tend to study about what they expect to be evaluated, cumulative assessment can influence learning even in the absence of feedback.

The skills evaluation is a challenge in itself because not all evaluation methods are useful for different levels of competence (36). A limitation of the evaluation is that it may not demonstrate real future performance. The evidence that the evaluation protects the public from poor quality care is both indirect and scarce; it consists of a few studies that show correlations between assessment programs that use multiple methods and relatively rudimentary estimates of quality, such as diagnostic tests, prescription, and remission patterns (37).

Correlating the evaluation with future performance is complex, not only due to the evaluation process itself but to the limitation of training and its relationship with future performance.

1.4. Innovative strategies in emergency training.

The World Health Organization (WHO), numerous international scientific societies as well as various investigations have considered the potential impact of the use of digital technologies as a mechanism to act on health (32,38-45).

The use of mobile and wireless technologies has the potential to transform the aspect of the provision of health services worldwide. In this sense, WHO uses mobile technology in its Be He@althy, Be Mobile (BHBM) program. Through this initiative, it disseminates different health prevention programs. It is present in more than 11 countries reaching more than 3.5 million people (38).

Due to the nature of social and mobile data, the information can be updated instantly and facilitate dialogue or exchange between public individuals and the health system.

New technologies have the potential to transform not only training and evaluation but the provision of health services (table 2).

Table 2: Innovative strategies applicable to emergency training

Simulation
Applications for mobile phones (APP)
Game-based learning (Gamification)
Social networks
Open Collaboration (Crowdsourcing)
Blogs and distributed multimedia files (podcasts)

Simulation.

Simulation can be defined as a pedagogical method that uses one or more techniques or equipment in an experiment aimed at promoting, improving or validating the progression of a participant (178). This learning experience aims to mimic the reality of the clinical environment.

Simulation is associated with positive effects compared to no intervention (108). Several reviews have confirmed that improved simulation with technology, compared to no intervention, is associated with large positive effects (108,171).

In this sense, simulation is a powerful tool that allows train and improve skills (106). The simulation allows educators to create experiences that foster learning in an environment that does not compromise patient safety (109). During the simulation, students are exposed to different situations that offer them the opportunity to train

patient assessment, decision-making, communication, and teamwork skills (179).

The repetitive and deliberate practice of medical simulations is associated with the improvement of student results (171).

Simulation-based practice in medical education seems to approximate a dose-response relationship in terms of achieving the desired results: "more practice produces better results" (180). Therefore there is an association between longer training time and better results (180).

In addition, simulation-based training for the learning of critical events has proven highly effective (107,108), and can also be useful for the evaluation of knowledge, clinical reasoning, and teamwork (111) .

Students are satisfied with the simulation because it allows them to objectively perceive their evolution, thus increasing awareness of real skills (181).

Thousands of individual research reports synthesized in five comprehensive reviews reveal that simulation is a powerful educational tool that increases the competence of students in the simulation room, during patient care, improving patient health outcomes. Therefore simulation training has direct effects on the health of patients (171,180,182–184).

Issenberg et al (183) propose the characteristics that simulation training should have to facilitate learning (table 3).

Table 3: Simulation characteristics that can facilitate learning (183).

Provide feedback
Repetitive practice
Integrated in the curriculum
Adequate difficulty level
Multiple learning strategies
Simulators with the ability to simulate a large clinical variety
Controlled environment
Individualized learning
Defined results
Validity of the simulator

Applications for mobile phones (APP).

Reportedly, there are more than 7,000 million mobile phone subscribers worldwide, more than 70% of which are in low or middle income countries. In many places, people are more likely to have access to a mobile phone than to clean water (38).

In the United States, the presence of mobile phones reaches 285 million (185). More than 50 million of these devices are smartphones, capable of offering advanced wireless services, Internet connection, running mobile applications (APP)… (185–187).

The presence of smartphones and "tablets" has led to the generation of numerous implementation approaches through the use of APPs (table 4) (32).

Table 4: Categories of APPs according to the implementation approach.

APP showing information about resuscitation algorithms (188).
Applications that use user geolocation to show the location of the nearest AED.
Interactive APPs that create an immersive and interactive means to educate users.
Combined learning packages for life support courses.
Feedback devices. Real-time use of the accelerometer to receive indications about CPR parameters (189,190).
Notification and activation of passersby next to the CRA. The use of these systems can lead to faster response times compared to emergency service assistance (92,93).

Learning based on game and competition (Gamification).

Game-based learning, gamified learning or gamification, is the use of game attributes with the purpose of affecting behaviors or attitudes of a task related to learning (191,192).

The use of games has been used for emergency training with different formats; application of games for training of skills, games with avatars, games that use interactive platforms… (193-200).

The implementation of the elements of the game can improve intrinsic motivation by satisfying innate psychological needs in terms of autonomy and competence (201–204). The games have demonstrated their potential, combined with training, to complement emergency training (199) (205) or as an evaluation method combined with simulation (199).

However, there is no conclusive data to suggest that the use of gamified learning improves response and performance in real settings outside the training environment (for example, the willingness to act, performing cardiopulmonary resuscitation, the use of DEA) in real cardiac arrest scenarios (42).

Social networks in training and evaluation.

Social networks have more than one billion users who share information, publications, status updates, location, etc (206). That is why they are increasingly used to reach a large global audience.

The use of social networks in the field of training has advantages and disadvantages (Table 5).

But the advantages of social networks go beyond training. Several studies (213) and a scientific statement (41) have evaluated the potential of social media in emergency research. Some of the most used social networks are Facebook, YouTube, Twitter...

Platforms like YouTube are used to disseminate knowledge in emergencies with disparate results. As an example, several studies have shown that CPR instruction, on that platform, contained information that could be useful, but many videos had incomplete information, showed low quality compressions and instructions were inaccurate (214–216)

Twitter is another platform with enormous potential in the transmission of information. Many tweets related to emergencies, specifically with resuscitation, were identified as information search tools and training (213,217).

Table 5: Advantages and disadvantages of the use of social networks in the educational field (207-212).

Advantages
Connection opportunity between individuals
Participation of students in the creation and dissemination of knowledge.
It facilitates commitment, reflection, and active learning.
Possibility of using different modalities (video, images …)
Participatory learning. Knowledge is generated through the exchange of information and distributed through connections between students
Drawbacks
Limited dates of rigorous program evaluations
Its use is a source of distraction
Private Information Exposed
Difficult differentiation between professional image and personal/private image
Share material protected by copyright and / or intellectual property
Very unequal or erroneous/misleading quality information
Variability in use between teachers and students

Open Collaboration (Crowdsourcing)

Crowdsourcing seeks the interaction of the population or individuals in a particular way to perform certain actions. It is defined as the attempt to reach groups of individuals to perform a task (218).

Crowdsourcing represents an emerging application that has been used to access and mobilize millions of people to contribute to the advancement of science (219,220). The MyHeartMap challenge was a crowdsourcing research project that involved the population of Philadelphia County. The objective was to locate automatic external defibrillators (AED) to create a map and database of installed devices (221).

Crowdsourcing can be used to involve large and diverse groups of people to participate in research, study digital strategies, connect networks in emergencies and raise awareness about health conditions, including emergency cardiovascular conditions (219,220,222–224).

Blogs and distributed multimedia files (podcasts)

Blogs are a serialized and self-published platform for disseminating information (225) and podcasts are an audio-based content distribution platform (226). They are evolving as valuable communication tools for the dissemination of information. They are attractive because they can include not only text but also embedded links, images, and interactive components.

Many studies have focused on the potential of blogs and podcasts to improve the dissemination of research. Blogs and podcasts have shown that they improve the number of readers and the promotion of academic publications, increase knowledge on various topics and improve communication and dissemination of education (226–232).

1.5. Visual tracking system and its possible role in adult training (Eye-tracking).

The eye-tracking system is a well established concept since it was first used in 1950 to study the visual behavior of pilots (46). This system has a device that focuses a camera towards the subject's eye so that pupillary movements can be recorded for later analysis.

Eye-tracking measures the behavior of the gaze during the execution of the task, which allows knowing data on decision making. In addition to the movement of the pupil, this system allows measuring several ocular variables including the frequency of fixation and the time of fixation (used as an indirect measure of the importance of the perceived stimulus) (46,58), as well as the dilatation of the pupil, a marker of effort and subject concentration (233,234).

This is a tool used for training and learning (115,136–138,235–238). Eye-tracking has been proposed, for example, as an appropriate training method in the operating room, where strict sterility should be maintained. In this sense, a visually guided interface would help this use (238).

The development of valid, reliable methods and skills assessment objectives is essential for training (47). In this sense, the eye-tracking system is a method used for evaluation (48–62) and can measure different skill levels (48–50,52,54,55,58,60,63–65).

The eye-tracking system is used in research in sports, medicine, nursing, lifeguard, aviation, safety, etc. (113,114,239–264).

Eye-tracking measures the behavior of the gaze during the execution of the task, which allows researchers to collect data on the clues used during the reasoning. Not all gaze behaviors are consciously remembered, and therefore can allow researchers to detect unconscious clues that can affect the reasoning process (265)

In general, studies show different visual behaviors between expert professionals and those with less experience. In this sense, expert doctors have better diagnostic accuracy, they need less time to first detect the abnormal pattern. However, experts are not necessarily more efficient in the diagnostic task (266,267). Rather, they generate more theories and possible diagnoses in the given time (266).

Research in cognitive psychology has shown that experts tend to have little overlap in their reasoning process, due to the "shortcuts" acquired over time (268).

Therefore, the Eye-tracking System offers the possibility of obtaining a new perspective of reasoning and a better knowledge of the decision-making process.

1.6. Opportunities that new technologies offer to training in the field of emergencies.

According to the Guidelines of the European Resuscitation Council 2015, first aid can be initiated by anyone in any situation. A first aid provider is defined as someone trained in first aid who should (269):

- Recognize, evaluate and prioritize the need for first aid;
- Provide attention using appropriate skills;
- Recognize limitations and seek additional attention when necessary.

The objectives of first aid are to preserve life, alleviate suffering, prevent more illness or injury and promote recovery.

This definition of "first aid" for 2015, created by the ILCOR First Aid Working Group, addresses the need to recognize injuries and illnesses, the need to develop a specific skill base and the need for first aid providers to provide simultaneously immediate care, and activate Emergency Medical Services or other medical care as necessary.

In 2003, Chamberlain and Hazinski (66) estimated the functioning of the chain of survival at the local level, which depends primarily on laypeople, and established an ideal to be achieved (Table 6). This ideal would have the potential to save the lives of patients victims of an emergency CPR situation.

Table 6: Survival formula; indicators (66).

	Quality of recommendations	Efficient training of health personnel	Good functioning of the chain of survival locally	Relative survival of patients. Theoretical potential
UTOPIAN	1	1	1	1
IDEAL	0.9	0.9	0.9	0.72
CURRENT	0.8	0.5	0.5	0.20
ACHIEVABLE	0.8	0.9	0.5	0.32

The American Heart Association, in the year 2018, in the document "Educational strategies to improve the results of cardiac arrest" (42) indicates that the formula for survival depends fundamentally on educational efficiency and the local implementation of training programs, these two factors being, determinants in survival.

These survival formulas show the potential that appropriate interventions on first responders may have on survival in an emergency situation.

The low participation of first responders in an emergency situation offers an opportunity for improvement. Efficient training and evaluation, consistent with scientific evidence as well as the use and exploitation of new technologies have the potential to save thousands of lives of victims of emergency situations (45). In this sense, the use of simulation and the eye-tracking system can be useful technologies to achieve these objectives (image 1).

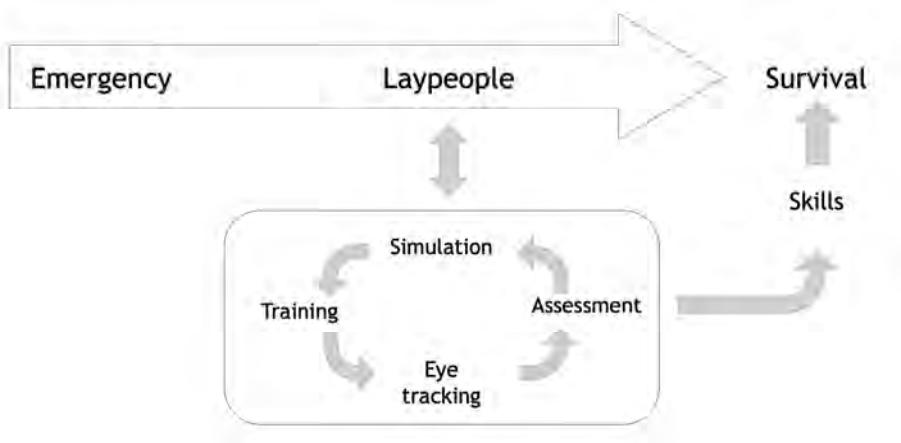

Image 1: Factors with influence on the improvement of survival in an emergency. Own elaboration.

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HYPOTHESIS

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2. HYPOTHESIS

- Simulation and the eye-tracking system are useful tools to evaluate and know the degree of performance in simulated situations.

- Mobile applications with real-time feedback improve the quality of CPR performed by inexperienced people.
- Performing CPR by inexperienced people with a mobile phone in their hands decreases the quality of CPR.

- Professional lifeguards with theoretical training in primary assessment perform poor assessment in a simulated situation.
- During simulation with a critical patient, professional lifeguards focus their attention on the patient.

- Face-to-face training is more effective for the recognition and treatment of anaphylaxis than video training.
- Faced with a simulated case, teachers will focus their visual fixations on the victim of anaphylaxis.
- After receiving video training or face-to-face training, teachers will perform an adequate treatment of anaphylaxis.

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OBJECTIVES

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3. OBJECTIVES

The main and secondary objectives of this research are;

1. Assess the use of simulation and automatic pupil tracking technology (eye-tracking) as a method of performance evaluation in various emergency situations.

2. Evaluate the quality of cardiopulmonary resuscitation (CPR) of non-experts guided by a mobile application (APP) with real-time feedback.
   2.1. Evaluate whether performing CPR with a mobile phone between the lifeguard's hands interferes with the quality of resuscitation.

3. Assess decision making and the degree of performance in primary assessment in a simulated situation by first responders.
   3.1. Know the visual pattern of first responders in the assessment of a simulated critical situation.

4. Compare in a simulated environment the usefulness of two training models (video vs. face-to-face) for the recognition and treatment of anaphylaxis.
   4.1. Know the visual pattern of teachers in the resolution of a simulation with a patient with anaphylaxis.
   4.2. Determine the level of competence of teachers in a simulated anaphylaxis situation.

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RESULTS

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4. RESULTS

This thesis follows the modality of the compendium of articles. Therefore the results are presented as research articles.

In this section, three articles are presented as the main results of this study. These three articles constitute the central core of this thesis.

Before the presentation of each article, magazine references and data on the quality of the publications are included. All articles passed a peer review process and were published during the doctoral period.

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4.1. Article 1.

Original title:

Evaluación sobre la técnica de compresiones torácicas usando APP. ¿Ayudan o entorpecen la reanimación cardiopulmonar?

Evaluation of the thoracic compression technique using APPs. Do they help or hinder cardiopulmonary resuscitation?

Authors:

Felipe Fernández Méndez, Roberto Barcala Furelos, Martín Otero Agra, María Fernández Méndez, Myriam Santos Folgar, Antonio Rodríguez Núñez.

Identification of the article:

DOI: 10.1016/j.medin.2018.07.015

PMID: 30270143

Identification of the journal:

Medicina intensiva

ISSN: 02105691

Impact factor: 1.982

CiteScore: 0.81

51 st percencile / 38/80 / Critical Care and Intensive Care Medicine

SNIP: 0.441

SJR: 0.334

Doctoral student contributions

In relation to this article, the Ph.D. student participated in the design of the study and methodology.

He was responsible for the selection of the sample following the inclusion and exclusion criteria and reported on the objective and methodology.

He participated in the fieldwork and codified the data obtained.

Finally, he wrote the article according to the rules of the magazine. As a correspondence author, he made the corrections and revisions requested by the magazine and sent all the necessary documents for publication.

4.1.1. Evidence of Quality

Citation up to august 2019

1. Carballo-Fazanes A, Jorge-Soto C, Abelairas-Gómez C, Bello-Rodríguez J, Fernández-Méndez F, Rodríguez-Núñez A. Could mobile apps improve laypeople AED use? Resuscitation. 2019;140:159-160. (188)

Paper subjective evidence quality.

PlumX Metrics:

- Field-Weighted Citation Impact: 1.72
- Captures:
  - Readers (Mendeley): 10
- Researchgate:
  - Research interest: 0.6
  - Recommendations: 1
  - Reads: 15

Journal subjective evidence quality.

Intensive medicine is a monthly medical journal and peer review. It focuses on the attention to critical care as well as the attention to cardiorespiratory arrest.

Intensive medicine is the official journal of the Spanish Society of Intensive, Critical Medicine and Coronary Units (SEMICYUC).

4.1.2. Article abstract including main results

Objective: To evaluate the quality of cardiopulmonary resuscitation (CPR) of non-experts guided by a mobile application with real-time feedback.

Methods: A quasi-experimental cross-sectional study was conducted. A sample of 113 Nursing students without experience or training in CPR participated in the study. Three hands-free CPR tests were performed with continuous compressions: 1) CPR without a device, 2) CPR with the phone off, 3) APP-guided CPR. Three different applications were randomized [Pocket CPR®, CPR Pro® and Massage cardiaque et DSA®]. The three tests were performed consecutively, randomized and separated 30 minutes between each one. The mannequin Laerdal Resusci Anne QCPR (Stavanger, Norway) software 2.0.0.14 was used.

Results: The overall quality of the CPR was 33.3% + 32.7 for Pocket CPR, 10.9% + 22.72 for CPR Pro and 7.8% + 9.2 for Massage cardiaque et DSA. With none of the APPs, statistically, significant improvements are achieved. The percentage of time that the rescuer managed to maintain the correct rhythm improved with the use of the three APPs.

Conclusions: APP-guided CPR did not improve the overall quality of compressions during resuscitation, although the percentage of compressions performed at the correct rate improved.

Limitations: This is a study with dummies so the results may not be transferable to clinical practice. The results of using an APP in a real victim or in a scenario that is not simulated can generate different data. All participants used the same Smartphone, this can also be a limiting factor since not all phones have the same sizes and the same features, therefore the findings have to be taken with caution. The lack of technical training for the subjection of the Smartphone or the lack of experience of the subjects can be another limiting factor.

Evaluación sobre la técnica de compresiones torácicas usando APP. ¿Ayudan o entorpecen la reanimación cardiopulmonar?

http://www.medintensiva.org/es-evaluacion-sobre-tecnica-compresiones-toracicas-avance-S0210569118302444

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4.2. Article 2.

Original title:

ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross sectional simulation study

Authors:

Felipe Fernández Méndez, Martín Otero Agra, Cristian Abelairas Gómez, Nieves María Sáez Gallego, Antonio Rodríguez Núñez, Roberto Barcala Furelos.

Identification of the article:

DOI: 10.1371/journal.pone.0212080

PMID: 31039154

Identification of the journal:

PLOS ONE

ISSN: 19326203

Impact factor: 2.776

CiteScore: 3.02

89 th percencile / 20/185 / General Agricultural and Biological Sciences

SNIP: 1.123

SJR: 1.100

Doctoral student contributions

The Ph.D. student participated in the design of the study.

The student planned and participated in the fieldwork to obtain the data. He was in charge of informing the sample of the objectives and methodology of the study, programming the simulator for the standardized clinical case and the observation and data collection of the different simulations. Once this was done, he performed the data coding.

Finally, he wrote the article according to the standards of the magazine and made the corrections and revisions requested by the reviewers.

4.2.1. Evidence of Quality

Paper subjective evidence quality.

PlumX Metrics:

Usage:

- Full Text Views: 413
- Abstract view: 16
- Link-outs: 1

- Captures:
  - Readers (Mendeley): 5
- Social Media:
  - Tweets: 1

Researchgate:

- Research interest: 4.9
- Recommendations: 1
- Reads: 99

Journal subjective evidence quality.

PLOS ONE is a magazine published by the Public Library of Science (PLOS). It is an international Open Access publication that covers research in any subject related to science and medicine.

4.2.2. Article abstract including main results

Objective: Evaluate decision-making, the ability to use the ABCDE approach and the approach skills of first responders when facing a simulated case that requires critical care.

Methods: A cross-sectional simulation study was desing, to evaluate the skills and sequence of the ABCDE approach in 20 professional lifeguards. Demographic variables were collected, as well as variables related to ABCDE approach ability and ABCDE eye-tracking approach variables.

The subjects were evaluated by three BLS and ALS instructors as well as by the Mobile Eye system (Bedford, USA).

Results: None of the study participants successfully completed the primary assessment. Around 60% of fixations and fixation time was dedicated to areas of vision important for the ABCDE approach, finding significant differences when compared with unimportant areas of vision ($p < 0.008$).

Conclusions: The first responders of this study take the initiative to perform ABCDE approach, however, the sequence order is variable and the accuracy of the skills is not adequate. Expert evaluation with the help of pupil tracking technology identifies limitations in assessment and treatment and can be a useful tool for training lifeguards.

Limitations: This is a simulation study so a real intervention could generate different results. The lack of experience of the participants in the use of simulation could be a limiting factor.

ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross sectional simulation study

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0212080

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4.3. Article 3.

Original title:

Learning and Treatment of Anaphylaxis by Laypeople: A Simulation Study Using Pupilar Technology

Authors:

Felipe Fernández Méndez, Nieves María Sáez Gallego, Roberto Barcala Furelos, Cristian Abelairas Gómez, Alexis Padrón Cabo, Alexandra Pérez Ferreiros, Carlos García Magán, José Moure González, Onofre Contreras Jordán, Antonio Rodríguez Núñez.

Identification of the article:

DOI: 10.1155/2017/9837508

PMID: 28758128

Identification of the journal:

BioMed Research International

ISSN: 23146133

Impact factor: 2.583

CiteScore: 2.41

70 th percencile / 57/189 / General Biochemestry, Genetics and Molecular Biology

SNIP: 0.951

SJR: 0.795

Doctoral student contributions

In relation to this article, the Ph.D. student participated in the design of the study and methodology.

He communicated in writing the objective and methodology of the study and, together with his colleagues, carried out the selection of the sample, in accordance with the established inclusion and exclusion criteria.

He planned and participated in the fieldwork to obtain the data and codified the data obtained.

Finally, he wrote the article according to the instructions of the magazine.

4.3.1. Evidence of Quality

Citation up to august 2019

1. Fernández-Méndez F, Otero-Agra M, Abelairas-Gómez C, Sáez-Gallego NM, Rodríguez-Núñez A, Barcala-Furelos R. ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross sectional simulation study. PLoS ONE. 2019; 14(4):e0212080. (263)
2. Matricardi PA, Dramburg S, Alvarez-Perea A, Antolín-Amérigo D, Apfelbacher C, Atanaskovic-Markovic M et al. The Role of Mobile Health Technologies in Allergy Care: an EAACI Position Paper. Allergy. 2019. [Ahead of print]

Paper subjective evidence quality.

PlumX Metrics:

- Usage:
  - Full Text Views: 253
  - Abstract view: 262
  - Link-outs: 25
- Captures:
  - Readers: 22
  - Exports-Saves: 37

Researchgate:

- Research interest: 3,4
- Recommendations: 1
- Reads: 107

Journal subjective evidence quality.

BioMed Research International is a peer-reviewed Open Access magazine that publishes research articles from 55 thematic areas including medicine.

4.3.2. Article abstract including main results

Objective: Evaluate two training models on the recognition and treatment of anaphylaxis for non-experts, based on the assessment of experts and pupil technology.

Methods: A quasi-experimental, cross-sectional simulation study was conducted to evaluate the identification and treatment of anaphylaxis. 50 subjects were randomized into 4 groups: 3 used different videos with content supervised by health staff and was compared with a face-to-face training in pediatric consultation. For the evaluation of learning, a simulation scenario was designed in which a victim of anaphylaxis was represented. An eye movement recording device and expert assessment were used to assess performance.

Results: Pediatric face-to-face training gained better and faster recognition of anaphylaxis. Participants used the adrenaline injector with greater precision and fewer errors. With this type of training, participants needed a smaller number of visual fixations to recognize anaphylaxis and make the decision to inject epinephrine.

Conclusion: A face-to-face training given by a pediatrician improves the recognition of anaphylaxis and the probability of the correct use of an injector. Training videos can be a useful resource, but with great variability in their effectiveness.

Limitations: As with other simulation studies, the results should be considered with caution in the case of real victims.

Learning and Treatment of Anaphylaxis by Laypeople: A Simulation Study Using Pupilar Technology

https://www.hindawi.com/journals/bmri/2017/9837508/

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DISCUSSION

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5. DISCUSSION

The main objective of this doctoral thesis work, through a compendium of articles, the evaluation of various simulated situations for the study and understanding of skills, learning and the application of first aid techniques by both lay witnesses and with the obligation to intervene.

Intervention in an emergency and with first aid application occurs infrequently and erroneously in many cases (21). Some studies have shown those witness interventions and care resulted in a possible improvement in survival but the frequency and quality of first aid provided varied greatly (21). CPR performed by pedestrians is critical for survival in out-hospital cardiac arrest (OHCA) (32) it is well established that high-quality cardiopulmonary resuscitation is associated with better survival outcomes in case of cardiac arrest (141).

Survival formulas (42,66) show the potential that appropriate interventions on first responders may have on survival in an emergency situation.

Following this line of priorities, this research has tried to provide evidence on new technologies and training methodologies. To our knowledge, this is the first research that deals globally with the use of feedback as well as simulation and evaluation with eye-tracking in non-health personnel.

Feedback via mobile applications.

Improper performance of CPR is common but difficult to detect for providers and instructors (67,68). In theory, technology could help address this problem by evaluating the performance of cardiopulmonary resuscitation and providing feedback. In this sense, the feedback devices that provide information on compression depth, rhythm, re-expansion, and hand position during training improve the level of competence acquisition at the end of the training (26,69-89).

Mobile applications have revolutionized in many ways the learning of CPR (90) or the activation of witnesses close to accidents, achieving an increase in the performance of CPR by parties involved (91-93).
There is numerous research on CPR with feedback and the improvement of the quality of resuscitation of both laypeople and health professionals (26,79,94–96)… Mobile technology through the use of APPs aims to offer the first participant a tool that provides real-time feedback on the CPR performed. Our study investigated the efficacy of chest compressions by comparing three APPs.

The subjects of this study did not improve the results with CPR guided by APP and in some cases even worsened. Other studies have shown that different devices that offer feedback increase the quality of chest compressions, especially rhythm and depth when used by people with CPR training (84,97). The students of this research had no previous training and their first contact with the CPR was the initial familiarization with the APP before the tests. The lack of instrumental practice can be an important limiting factor.

The APPs in this study did not improve the depth of compression, perhaps due to the lack of ability of the resuscitators, due to the lack of precision of the APP or due to the discomfort that CPR can generate with the telephone linked in the hands. Other devices that release the hands are available in the market and maybe an alternative (98).

The depth of the compressions has been insufficient in all the tests performed, even with the use of APPs. Not reaching the right depth is

a concurrent factor in numerous studies with laypeople (99). Various reasons can cause a lack of depth. However, the use of APPs has managed to maintain the frequency of compressions at significantly higher values when compared to the other tests. In CPR guided by devices with feedback, improvements in rhythm have been found (100-101). However, simple elements such as music, led devices or metronomes can improve this variable (100) without the need to occupy the hands although there is evidence that they can reduce the depth of compression as the subject focuses on the correct rhythm (76,88,89).

The study by Park J. et al. evaluated the use of the PocketCPR application by placing the smartphone in three positions (held by a hand, with a bracelet on the hand and with a bracelet on the arm). In any of the three cases, the thoracic compression depth measurements obtained did not show validity for any of the three sites attributing the error to the system by which the data is obtained, the accelerometer (270).

Although there are several applications for resuscitation training, not all adhere to the recommendations of scientific societies and their accuracy and usability are not tested (271). Because of this, the quality of resuscitation may vary depending on the feedback device used (70).

The use of a feedback device should be used when there are statistical tests of validity and reliability as a measuring tool (102). In this line and following the recommendations of the US Food and Drug Administration (FDA) (103) a regulation on medical APP is necessary in order to ensure its validity and reliability. Therefore, the use of digital strategies should be evaluated in a similar way to other medical interventions, including formal evaluations such as the 6 domains of the quality of medical care identified by the Institute of Medicine: safety, efficacy, patient-centered, timely, efficient and equitable (104).

Sometimes the mechanisms designed to improve CPR, if there is no formation, training or experience, do not achieve their purpose.

Therefore, the use of feedback devices during CPR should only be considered as part of a broader system of care (105) rather than as an isolated intervention.

Eye tracking. Simulation.

A simulation is a powerful tool that allows us to train and improve skills (106) having proved highly effective for training critical events (107-108). The simulation allows educators to create realistic experiences that foster learning in an environment that does not compromise patient safety (109), as well as train a range of roles from the first response to the CRA to the direction of a CPR team.

Simulation training is an integral part of emergency training. A systematic review and meta-analysis of 182 studies that included 16,636 participants in simulation training for resuscitation showed an improvement in knowledge and performance of skills compared to training without simulation (110).

The use of valid, reliable methods and skills assessment objectives in critical situations is essential in modern training. High-tech simulation is increasingly considered an important learning aid and can be useful in the evaluation of knowledge, clinical reasoning, and teamwork (111,112).

Similarly, the eye-tracking system has been proposed as a potential assessment tool used in multiple fields and various studies (48-65).

Eye-tracking technology allows us to recognize visual variables (48,49,53,58,59,62,63,113-115) and establish patterns that help to understand the clinical reasoning involved in decision making.

Using these technologies (simulation and eye-tracking) we have carried out the first investigations in which the care provided in emergency situations by non-health personnel is evaluated.

The lifeguard is the person in charge of safety (116) prevention and rescue (117) in aquatic environments. First aid care is not a common

task since it represents a very low percentage of the total actions taken by first responders (118), however, when the incident occurs, every second count and adequate and quality care should be provided. It has been tried to know the capacity of lifeguards in the use of the primary assessment using simulation and the eye-tracking system.

Professional lifeguards showed differences in recognizing and treating a critical patient in a simulated situation. All study participants had theoretical training and knew what it was and how the primary assessment was applied but had not received training with simulation and 55% had not used the primary assessment in a real situation.

Lifeguards in this study evaluated Airway (70%) and Breathing (85%) although only Airway 20% and Breathing 25% did so correctly. In fact, the assessment of Breathing was correctly performed by 5 subjects. Only 40% evaluated Circulation. Of the subjects who performed the Circulation evaluation, only 3 took a central pulse and 2 peripheral pulse Despite this step, the Circulation valuation was the one that required the most time to carry out its valuation (45sec). This may be due to the bleeding presented by the simulator in the lower limb. Hemorrhage was a distracting factor introduced by the researchers. This was of a very small amount, produced by erosion. The majority of subjects in this study did not consider assessing the peripheral or central pulses. This could be because the Guidelines of the European Resuscitation Council (119) as well as the Guidelines of the American Heart Association (120) of basic life support, insist that taking the pulse is not a necessary measure to establish the diagnosis of cardiorespiratory arrest. However, the simulator did not present a CRA and required a Circulation assessment.

The application of a structured system of assessment has become the norm in trauma. This approach to early recognition and treatment of life-threatening injuries has been trained in trauma courses for decades (121,122). In the study by Olgers et al. in which they investigated the use of the ABCDE approach by doctors from an emergency

department, they observed that this approach was used in 26% of the patients. When ABCDE approach was used it was done with high scores (83%). The reason why the doctors decided not to use this assessment approach was due to the general clinical impression, the vital signs registered by nursing or that the reason for the consultation does not suggest an unstable patient (123). In another study conducted in a hospital emergency department, it was found that 52% of the patients were evaluated with the ABCDE approach, and 17% were fully and accurately evaluated (124).

In view of our results, it seems that the first responders of our research are below in terms of compliance with the ABCDE protocol. With respect to visual fixations, lifeguards maintain adequate attention and fixation, that is, they are focused on looking. Around 60% of the fixations and the time of visual fixations were dedicated to areas of vision important for the ABCDE approach. This is independent of the decisions made at all times. He may be focusing his gaze but not knowing the decisions to be made.

Eye-tracking. Simulation. Standardized patient

Standardized patients are actors who are trained to portray patients consistently on repeated occasions (111). Interactions with standardized patients can be adapted to meet specific educational objectives so that the actors who represent the patients can rate the performance of the intervener in the simulation. Structured evaluations with the use of standardized patients are as reliable as the qualifications of the meetings directly observed with real patients (125-127). Through the use of standard patient and eye-tracking system we evaluate two training models (video vs. Face to face) and its application in a simulated case of anaphylaxis.

Different video training systems have reported success in teaching techniques related to emergencies (128,129). In our study, traditional face-to-face training provided by the expert staff has obtained better

results than video training. On the contrary, several studies on CPR had shown good results for video training (128,130).

The subjects of the group that has received the "face to face" training are the second fastest at the time of having the injector in hand and the fastest at the time of using and administering the epinephrine. The "face to face" group offers adequate treatment for anaphylaxis in 36 ± 21.5 seconds from the start of the scenario. Johnston, EB et al (131) found in a study conducted with anesthesia residents in an intraoperative simulation that the average diagnosis time of anaphylaxis was 7.6 ± 2.4 min and the time to administer epinephrine 6.5 ± 2.1 min. Greater emphasis is needed on the prompt recognition and appropriate treatment of anaphylaxis by health professionals (132).

The study by Arga, M et al (133) in which they evaluated the ability of doctors to use epinephrine injectors before and after receiving theoretical-practical training, found that errors in the use of auto-injectors may be related to the design of the same. In our study, we have observed that the improper handling of the autoinjector is more frequent in the groups formed by video. The group that received the face to face training did not make any mistakes in its manipulation.

In view of the results it seems that in our study the errors in the manipulation of the injector are more related to the training received than to the design of the autoinjector itself. In the study by Grouhi, M. et al (134) in which the skills of doctors, nurses and pharmacists in the use of epinephrine auto-injectors were evaluated, the majority of participants 75% did not demonstrate the ability to use the device properly. In our study the percentages vary from 100% of inappropriate use to 61.5% depending on the training received.

Subjects who have received face-to-face training recognize the symptoms of anaphylaxis more quickly and with less visual fixations and are more likely to effectively administer anaphylaxis treatment. These subjects make less visual fixations on the signs of anaphylaxis

than the other groups. This may be due to the fact that due to their formation they recognize the signs of anaphylaxis more quickly so they do not require so many fixations. On the other hand, the two groups that make the most visual fixations are the ones that offer the worst treatment.

Experts, compared to non-experts, have shorter duration fixations, more fixations in areas relevant to tasks and fewer fixations in redundant areas (135). There are different visual patterns in experienced and novice professionals so that the identification of the areas of the gaze and the increase of the fixations in the experts allows the demonstration of these to the novices which could facilitate learning and skill (47). The look and fixings can be trained. In fields such as sports have shown improvements in performance (136–138).

The recognition of visual patterns can help to understand the reasoning involved in decision making. The use of simulation together with the knowledge obtained through gaze tracking devices can contribute to the optimization of training and the improvement of results in the provision of first aid.

LIMITATIONS

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6. LIMITATIONS

The studies carried out present some limitations that must be considered in order to assess the relevance of the results and in the design of new projects on the subject.

All the investigations have been simulated, so we cannot confirm whether these results are generalizable to the real clinical environment.

The research “Evaluation on the technique of chest compressions using APP. Do they help or hinder cardiopulmonary resuscitation? ”In which the usefulness of APP in the performance of CPR was evaluated, it had a sample composed of nursing students, so despite not having the training, they may have a different motivation towards CPR. other populations All participants used the same Smartphone, this can also be a limiting factor since not all phones have the same sizes and the same features, therefore the findings have to be taken with caution. The lack of technical training for the subjection of the Smartphone or the lack of experience of the subjects can be another limiting factor.

In the studies “ABCDE approach to victims by lifeguards: How do they manage a critical patient? A cross-sectional simulation study ”and“ Learning and Treatment of Anaphylaxis by Laypeople: A Simulation Study Using Pupilar Technology ”the lack of experience of participants in the use of simulation could be a limiting factor. The sample was small so the results should be taken with caution. The duration of the scenario could be a limiting factor. We do not know what could have happened if the scenario were more durable.

Participants knew they were under observation and this may have modified their performance (the Hawthorne effect: research participants alter their behaviors when observed) (272).

CONCLUSIONS

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7. CONCLUSIONS

1. **Simulation and pupil tracking technology (eye-tracking) are useful and reliable tools for assessing emergency performance.**

2. **APPs do not help to improve the quality of compressions.**

3. **Performing CPR with an interlaced mobile phone in the hands does not interfere with the quality of the CPR.**

4. **The first responders take the initiative to carry out the primary evaluation, however, the sequence order is variable and the accuracy of the skills is not adequate.**

5. **The first responders maintain adequate attention and fixation during the simulated situation. Around 60% of the fixations and the time of visual fixations were dedicated to areas of vision important for the ABCDE approach.**

6. **Face-to-face training is a more effective method than video training for the recognition and proper treatment of anaphylaxis.**

7. **The group of teachers who received face-to-face training ("face to face"), compared with the other groups, recognized anaphylaxis faster and with less visual fixations.**

8. **Face-to-face training generated faster and more correct anaphylaxis treatment compared to the other groups.**

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FUTURE PERSPECTIVES OPEN BY THIS RESEARCH

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8. FUTURE PERSPECTIVES OPEN BY THIS RESEARCH

Each new finding gives rise to a new research question and stimulates a new project. In this sense, it seems to us that casuistry should be extended with studies that correct the limitations of previous research.

The use of APPs during cardiopulmonary resuscitation has not been shown to improve quality. The existence of new smart devices (watches, rings...) with potential use in emergency situations invites you to explore the possibilities both in cardiopulmonary resuscitation and in other emergency situations.

The simulation has shown optimal results in terms of the acquisition of skills demonstrating direct effects on the health of patients (171,180,182–184). However, the precise simulation of high technology, generally expensive, simulator operators, instructors with specific training... All this generates high costs in the use of simulation. Low-cost simulation can be an alternative that generalizes and expands its use. Comparing the effects of the simulation with the low-cost simulation is an interesting area since the known more beneficial effects of the simulation would be linked to a more efficient cost-effective relationship.

Training with simulation in a realistic environment, such as the work environment, is an interesting area to explore. We have tested under simulated conditions the ability of professional lifeguards to perform a primary assessment in the care of critical patients and the ability of teachers to recognize and treat anaphylaxis. The use of simulation makes it possible to train with any type of patient in any situation.

Investigating the use of simulation in the professional's usual environment would allow knowing the degree of acquisition of technical skills as well as non-technical skills such as leadership, teamwork...

It is well documented that CPR skills may decline in weeks or months after traditional courses (39). ABCDE assessment skills as well as critical patient care are complex and require specific and continuous formation and training. Using deliberate practice strategies, deliberate rapid cycle practice, mastery learning... could generate positive effects on the care provided by laypeople.

The use of valid, reliable and objective methods for assessing skills in critical situations is an essential element of current training. In this sense, pupil tracking technology offers the opportunity not only to evaluate skills but to establish visual fixation maps and improve understanding of decision-making in emergency situations. Research has shown that there are different visual patterns depending on the training method and the subject's experience (135). People experienced in certain situations share visual fixations. In the world of sports, gaze training and fixings have been used to improve performance (136–138). Getting to establish visual fixation maps for certain emergency situations and use these maps in training could have positive effects on performance. Knowing whether this visual training has the same effects as in the sports field is a mystery to solve.

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